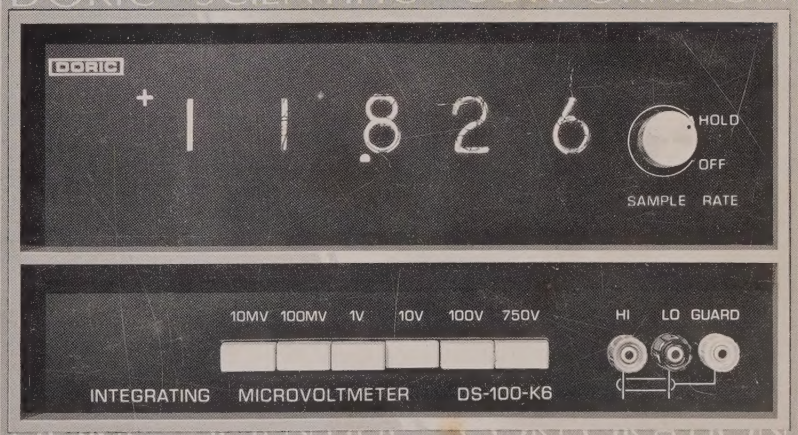
L.R. REID

Shop

INTEGRATING DIGITAL MICROVOLTMETER

WITH TRANSDUCER CONDITIONING FOR PHYSICAL AND SCIENTIFIC MEASUREMENT



OWNER'S MANUAL

DORIC SCIENTIFIC CORPORATION

Digitized by the Internet Archive
in 2026

https://archive.org/details/manualsplus_13032

DORIC SCIENTIFIC CORPORATION

shop

7969 ENGINEER ROAD • SAN DIEGO, CALIFORNIA 92111 • TELEPHONE 714/277-8421

DORIC SCIENTIFIC CORPORATION REPRESENTATIVES

Southern California

DORIC SCIENTIFIC CORPORATION
7969 Engineer Road
San Diego, California 92111
Ph. (714) 277-8421
(San Diego County only)

PRODUCT DATA COMPANY
1147 So. Robertson Blvd.
Los Angeles, California 90035
Ph. (213) 278-3356

Northern California

JAY STONE & ASSOCIATES
330 Second Street
Los Altos, California 94022
Ph. (415) 948-4563

Washington-Oregon

BRETT ASSOCIATES, INC.
2705 California Avenue, S.W.
Seattle, Washington 98116
Ph. (206) 935-8054

Colorado

HILLEARY ASSOCIATES
2552 Ridge Road
Littleton, Colorado 80120
Ph. (303) 794-4279
(Utah-Wyoming-Idaho call Zenith 7777)

New Mexico

HILLEARY ASSOCIATES
311 Washington S.E.
Albuquerque, N.M. 87108
Ph. (505) 265-7631

El Paso, Texas

HILLEARY ASSOCIATES
8888 Dyer, Suite 516
El Paso, Texas 79904
Ph. (915) 751-5491
(Arizona-Nevada call El Paso COLLECT)

Texas

Bill Morton — SESCO
Bill Rose
Chuck Chamberlain
231-9364

O'ROURKE ENTERPRISES
9503 High Meadow Drive
Houston, Texas 77024
Ph. (713) 782-6837
668 7840

Illinois

MEGATEK, INC.
1915 N. Harlem Avenue
Chicago, Illinois 60635
Ph. (312)889-1277
(Wisconsin call Chicago office)

Minnesota

MEGATEK, INC.
6810 Irving Avenue South
Minneapolis, Minnesota 55423
Ph. (612) 866-9769

Indiana

MEGATEK, INC.
Route 1
Freetown, Indiana 47235
Ph. (317) 988-7002

Michigan

ANDERSON ELECTRONICS
30785 Grand River Avenue
Farmington, Michigan 48024
Ph. (313) 476-9161

Ohio-Western Pennsylvania

INSTRUMENTATION SYSTEMS, INC.
3841 Office Park Drive
Dayton, Ohio 45439
Ph. (513) 293-8095
(Kentucky-West Virginia)

Upstate New York

LABTRONICS, INC.
130 Pickard Bldg.
Syracuse, N.Y. 13211
Ph. (315) 454-9314

Eastern New York

LABTRONICS, INC.
5 Arnold Drive
Kingston, N.Y. 12401
Ph. (914) 338-1604

Western New York

LABTRONICS, INC.
3568 Moyer Road
North Tonawanda, N.Y. 14120
Ph. (716) 695-1982

Maryland-Washington D.C.-Virginia

RON DAVIS ASSOCIATES
11215 Oak Leaf Drive, Suite 120
Silver Springs, Maryland 20901
Ph. (301) 593-4900

New England-Downstate New York-
New Jersey-Eastern Pennsylvania-
Southeast-& all other regions

Call DORIC SCIENTIFIC CORP.
San Diego, California
Ph. (714) 277-8421 COLLECT

Export Wire or write

DORIC SCIENTIFIC CORP.
7969 Engineer Road
San Diego, California 92111
Ph. (714) 277-8421

DORIC SCIENTIFIC CORPORATION

7969 ENGINEER ROAD • SAN DIEGO, CALIFORNIA 92111 • TELEPHONE 714/277-8421

TWO YEAR WARRANTY

Doric Scientific Corporation hereby warrants each instrument of its manufacture as follows:

1. At the time of delivery of each instrument to the original purchaser, Doric Scientific Corp. UNCONDITIONALLY WARRANTS that it shall be free from defects in parts, materials and workmanship; and

2. Commencing with the date of shipment of each instrument to the original purchaser, and for a period expiring TWO YEARS from said date, Doric Scientific Corp. UNCONDITIONALLY WARRANTS that each unit shall remain free from defects in parts, materials and workmanship.

In the event any instrument fails to meet the terms of this warranty, Doric Scientific Corp. agrees to provide corrective action. Refer to the Owner's manual for the proper procedure.

The warranties herein shall not obligate Doric Scientific Corp. in any manner whatsoever with respect to, and shall not be applicable to, any defects which after an inspection by Doric Scientific Corp. are not to Doric Scientific Corp.'s reasonable satisfaction demonstrably the result of defective parts, materials or workmanship. We are not liable for consequential damages.

CERTIFICATION

Doric Scientific certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when shipped from the factory. Doric Scientific further certifies that its calibration measurements are traceable to NBS.

DORIC SCIENTIFIC CORPORATION

7969 ENGINEER ROAD • SAN DIEGO, CALIFORNIA 92111 • TELEPHONE 714/277-8421

QUICK REACTION SERVICE

DORIC is organized to provide maximum up-time to all customers who have invested in DORIC instruments. The repair procedure we strongly recommend will get you "back on-the-air" faster than you could expect from any other type of service.

1. IMMEDIATELY on identification of some type of problem, refer to your Owner's Manual, Troubleshooting section. Review the section briefly to try to ascertain what corrective measures you may be able to perform with minimum effort.

2. Telephone the local sales representative of Doric. Their telephone number should be stamped on the front page of the original manual. Otherwise, check the appropriate sections of the EEM or EBG for a current listing. Advise the sales representative or his secretary that you are having problems. Give them the following information:

Your name
Company Name & Division
Area Code, Telephone, Extension
City and State
Complete Model Number (take from rear panel tag)
Serial Number and Shipping date (rear panel)

Our representatives have been instructed to wire or TWX this information to us immediately on receipt of your telephone message. Note: If you cannot easily locate our current representative, give us a collect call, identify yourself through the operator and hold for three minutes while we locate your contract files.

3. Within a few working hours of your initial call to our representative, and within minutes after our receipt of your distress signal, we will be calling you directly to troubleshoot the instrument by telephone. The modular construction together with the simplicity of design allows extreme ease of telephone isolation to a particular problem.

4. On identification of the problem, we will immediately act to ship the replacement part(s) or board to your home address by air mail. We can ship directly to your company address, if desired. However, this frequently requires more formal paperwork for both parties as well as inserting substantial time delays due to your receiving department, etc. Additionally, a small part has a high probability of getting lost in a large company or government agency.

We are generally willing to accept your word that any necessary purchase orders to cover the replacement parts will be issued through the normal and slower channels. Be assured that we want to help you solve the problem.

5, In rare instances, or should you prefer it, we may suggest that you return the instrument to DORIC for servicing. In these cases, please refer to the packing and shipping instructions in the manual. Failure to pack it properly can cause damage not covered by the warranty.

6. Turn-around time on factory repairs will rarely exceed two (2) days.

JET-PART

Rapid service and minimum down-time is dependent on the availability of spare parts. Your investment in a DORIC meter deserves fast parts service.

Inventories

Doric Scientific maintains an adequate inventory of spare and replacement parts of all standard instruments. Spare plug-in boards are stocked.

Parts Identification

As mentioned elsewhere, every DORIC Owner's Manual has a complete parts list. Each part is cross-correlated with the schematic reference to make it simple to determine which parts you want to order. For each part, the DORIC part number will be provided as well as the original manufacturer's number. Additionally, approximate prices are listed to simplify order placement.

Lead Time

Better than 90% of all orders for replacement parts received by DORIC will be shipped the same day. For routine parts requisitions for stocking purposes, as opposed to repair, please indicate your desired delivery.

Ordering Procedure

When ordering a replacement part or supply item, please specify:

1. the DORIC stock number for the part, and
2. its complete name as identified in the parts list, and
3. the model number and serial number of the instrument which these parts are intended for

TABLE OF CONTENTS

Paragraph		Page
	SECTION I - DESCRIPTION & OPERATION	
1-1	Introduction	1-1
1-2	DS-100 Mainframe, Description	1-2
1-3	Plug-In Facilities and Measurement Modules — Description and Operation	1-4
	SECTION II - UNPACKING, INSTALLATION, REPACKING AND CONNECTING UP	
2-1	General	2-1
2-2	Receiving Inspection	2-1
2-3	Installation	2-1
2-4	Repacking Instructions, Original Container	2-6
2-5	Input Connectors - Voltage Measurements	2-10
2-6	Connections for Minimizing Common Mode Noise Interference	2-10
2-7	Connections when using Digital Output Device	2-12
2-8	External Connections when using S3-1 and S4-1	2-16
2-9	External Connections when using P Options with S4-2	2-17
	SECTION III - SPECIFICATIONS	
3-1	DC Voltmeter Specifications	3-1
3-2	DC/DC Ratiometer Specifications	3-3
3-3	High Speed Measurement Specifications	3-3
3-4	Specifications for I/O Units S3-1, S4-1 and S4-2	3-4
3-5	General Specifications	3-5
	SECTION IV - THEORY OF OPERATION	
4-1	Introduction	4-1
4-2	System Theory	4-3
4-3	Circuit Description	4-6
4-4	Digital Circuits	4-7
4-5	Power Supplies	4-14
4-6	Analog Circuits	4-14
4-7	Self-Check Switch, Option B	4-21
4-8	High Speed, Option E	4-21
4-9	I/O Boards S3-1, S4-1, S4-2	4-22

TABLE OF CONTENTS (continued)

Paragraph		Page
	SECTION V - CALIBRATION	
5-1	General	5-1
5-2	Calibration Procedures	5-1
5-3	Equipment Required - All K Series & P Series Plug-Ins	5-2
5-4	Calibration of Single-Range Plug-Ins	5-2
5-5	Calibration of Multi-Range Plug-Ins	5-3
5-6	Calibration of Ratio Ranges	5-4
	SECTION VI - TROUBLESHOOTING	
6-1	Introduction	6-1
6-2	Notes on Circuit Analysis	6-1
6-3	Troubleshooting Programs	6-1
6-4	Pin Chart	6-8
6-5	Normal Power Supply Voltages and Load Resistances	6-9
6-6	Hold Condition Checkout Chart	6-9
	SECTION VII - PARTS LISTS AND SCHEMATICS	
7-1	Introduction	7-1
7-2	Basic DS-100 Parts List	7-3
7-3	Individual Parts - K and P Series	7-17
7-4	Options	7-29

LIST OF ILLUSTRATIONS

Figure No.	Title	Page
1.1	DS-100 K6 Automatic Integrating Microvoltmeter	1-1
1.2	Principal Components of Doric DS-100 Series	1-3
1.3	DS-100 with S3-1 and S4-1 Systems Application	1-11
1.4	Electronic Switches - Outputs	1-12
2.1	Line Voltage Setting	2-2
2.2	Detail of Latch, Stand and Shipping Screws	2-3
2.3	Rack Mount Option W - One DS-100 Mounted	2-4
2.4	Rack Mount Option W - Two DS-100 Mounted	2-5
2.5	Repacking Instructions - Original Container	2-7
2.6	Construction of Shipping Case	2-8
2.7	Guarding Techniques - Configuration I	2-11
2.8	Guarding Techniques - Configuration III	2-13
2.9	Connection to Digital Output Device, Showing Common Mode Path.	2-14
3.1	Outline Dimensions of Voltmeter	3-6
4.1	Simplified Diagram of Analog Circuits	4-2
4.2	Dual Slope Timing Diagram	4-2
4.3	Timing Diagram	4-4
4.4	CμL923 J-K Flip Flop	4-7
4.5	CμL914 Dual 2 Input Gate	4-8
4.6	CμL958 Decade Counter	4-9
4.7	CμL959 Storage Register	4-10
4.7A	CμL960 Decoder/Driver	4-10
4.8	Analog Switching Channel	4-16
4.9	Solid State Guard Crossing Block Diagram	4-23
5.1	Internal Calibration Panel	5-1

SECTION I

DESCRIPTION & OPERATION

1-1. INTRODUCTION

This manual provides full operational and service data for the Doric DS-100 K and P Series of Automatic Integrating Digital Microvoltmeters. Each of the precision test instruments in the series consists of a basic DS-100 Mainframe, into which is inserted the appropriate plug-in measurement module. As shown in Figures 1.1 and 1.2, the readout is incorporated in the mainframe, while the measurement function and range controls are located in the plug-in unit.

DS-100 INTEGRATING MICROVOLTMETER fig 1.1

Once the basic DS-100 mainframe has been purchased, any type K or P measurement module can be inserted into it to provide numerous measurement capabilities. Further, a number of options, some of which are themselves plug-in circuit boards, are used to extend the capabilities of the instrument. The resulting model numbers reflect the options and plug-ins chosen.

Types K and P, covered by this manual, offer precision multirange DC Voltage and DC/DC Ratio measurements over a dynamic range from the microvolt level to ±750VDC.

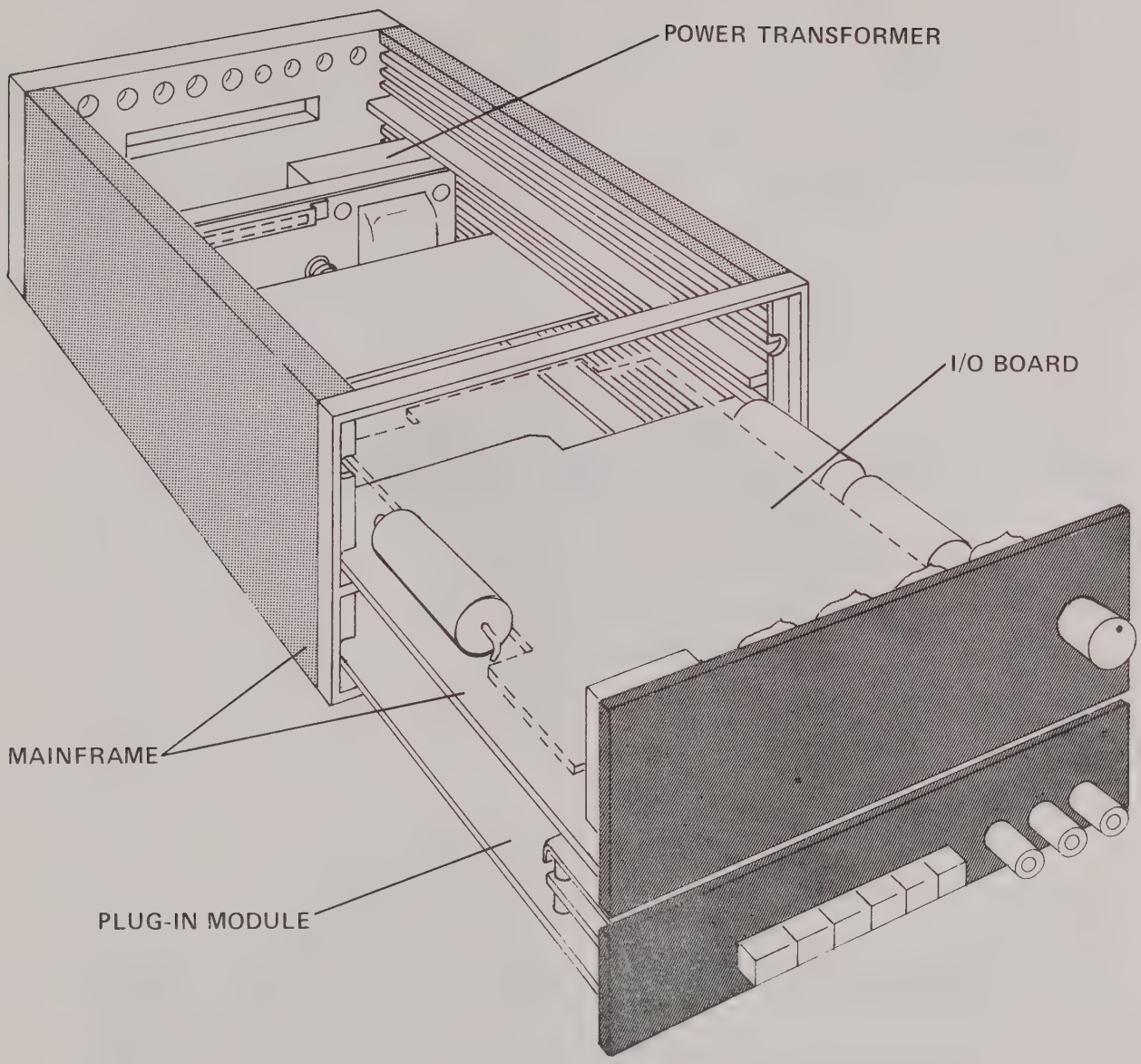
Other models in the Doric series are Type T3, specially designed for direct temperature measurements from thermocouples, and Type T2 for strain gage transducer measurements.

Separate manuals are devoted to the T Series, which include the necessary signal conditioning to enable the direct readout in engineering units of weight, force, microstrain, psi, degrees of temperature, etc.

Doric instruments combine their revolutionary AUTO-ZERO circuitry with a novel dual-slope integration technique to provide remarkable low level millivolt measurement accuracies and freedom from zero drift. All input circuits in all modules are fully floating, guarded and differential, so that true signal measurements can be made in grounded or ungrounded test configurations and in the presence of severe ground loops, recirculating currents and other sources of common mode interference.

1-2. DS-100 MAINFRAME, DESCRIPTION

The DS-100 mainframe carries the digital readout, the functional indicators, and the manual sample rate and power control. The mainframe is designed so that any of the Type K and P modules will plug into it. High-intensity Burroughs Nixie Tubes forming the in-line readout provide a sharp display of the measurement digits and decimal points; associated storage circuits hold the display constant during and between encodings. There is no blanking, blurring or last-digit flutter. The display storage feature permits visual tracking of the incremental digital changes in the value of a varying signal. An "S" symbol flashes with each new encoding to confirm that the voltmeter is sampling, even though the input signal and the digital indication may remain constant. An automatic "OL" overload symbol is displayed whenever the input exceeds the range or overrange limits of the meter; "R" symbol indicates ratio mode in operation; "MV" indicates that meter is displaying millivolts; "+" and "-" indicate the signal polarity. Automatic overranging extends the measurement capability to 120% of nominal full scale on the 10 millivolt through 100 volt ranges. The overrange "1" is a neon lamp.



PRINCIPAL COMPONENTS OF DORIC DS-100 SERIES fig 1.2

1-2-1. DS-100 MAINFRAME, OPERATION

The only control on the mainframe is a power switch S1 and SAMPLE RATE adjustment R6, operated by a single knob. Power is removed when the control is set fully counter-clockwise to OFF. Power is applied and the voltmeter starts encoding at the maximum sample rate when the control is moved clockwise from the OFF position. The sample rate decreases as the control is moved further clockwise. In the HOLD position (extreme clockwise) the voltmeter stores the reading indefinitely. When using the I/O boards the control should be set to HOLD, so that the voltmeter only responds to external sample commands.

1-3. PLUG-IN FACILITIES AND MEASUREMENT MODULES — DESCRIPTION AND OPERATION

Numerous fully-interchangeable plug-in modules can be used with the DS-100, as shown in the accompanying list, and described more fully below. These provide several alternative ranging combinations; an optional self-checking feature; DC/DC Ratio capability with unipolar variable reference; high speed and remotely-controlled interface operation and remote closure BCD data outputs for systems use. All Doric instruments are available either in rack mounting or bench mounting versions. A conveniently-located latch beneath the front bezel releases the plug-in module, allowing it to move freely outwards for calibration, adjustments, self-check, etc. without turning off the power.

1-3-1. MODELS K1, K2, K3 AND K4 PLUG-IN MODULES

Inserting Model K1, K2, K3 and K4 Plug-in accessory modules into the mainframe provides the instrument with the following single DC ranges:

Model	Range FS	Overranges to
K1	±10.000 millivolts	±12.000 millivolts
K2	±100.00 millivolts	±120.00 millivolts
K3	±1.0000 volts	±1.2000 volts
K4	±10.000 volts	±12.000 volts

PLUG-IN MEASUREMENT MODULES AND OPTIONS

Description	Model Numbers	
Single Range DVM 10 MV Full Scale	K1	Plug-In Modules
Single Range DVM 100MV Full Scale	K2	
Single Range DVM 1V Full Scale	K3	
Single Range DVM 10V Full Scale	K4	
Four Range DVM 10MV through 10V	K5	
Four Range DVM 1V through 750V	K5A	
Six Range DVM 10MV through 750V	K6	
Four Range Programmable DVM 1V through 750V	P1	
Six Range Programmable DVM 10MV through 750V	P2	
Four Range Autoranging DVM 1V through 750V	P1A	
Six Range Autoranging DVM 10MV through 750V	P2A	
Autorange Board	A	Options and Accessories
Self-Check	B	
DC/DC Ratios	C	
High Speed (20 readings per second)	E	
BCD Outputs (solid state closures)	S3-1	
BCD Outputs & Remote Program (solid state closures)	S4-1	
Remote Programming	S4-2	
Rack Mounting Adapter (with filler panel)	W	
Extender Board	X	
Rear Signal Inputs	Y	
Special Low Thermal Signal Input Cord Set	Z	

No range selector buttons are provided. A standard input lead is plugged into the front-panel banana jacks for signal "HI", signal "LO", and "GUARD", and the instrument is switched on. If option "C" is used to measure DC/DC Ratios with K1 through K4 plug-ins, the units function as single-range ratiometers only; they provide a single ratio range the same as the voltage range in the original instrument, but will not measure voltages as well as ratios.

1-3-2. MODEL K5 PLUG-IN MODULE

Inserting Model K5 plug-in accessory module into the mainframe provides the instrument with four discrete DC ranges, having full scale of ±10.000 millivolts, ±100.00 millivolts, ±1.0000 volt, and ±10.000 volts respectively. The meter will overrange to 120% F.S. on all ranges. Four interlocking push buttons are used to select the range required. If two or more buttons are pressed simultaneously no damage will result, but readings will be incorrect. When all buttons are released, the 10 volt range is automatically selected and the "OL" overload symbol flashes to indicate improper operation. Table below shows the attenuator settings, reference outputs, etc., which automatically come into operation as each range is selected.

RANGE CHART

RANGE	FULL SCALE INPUT VOLTS	ATTENUATOR SETTING	REFERENCE OUTPUT	A1 GAIN	BCD RANGE $R2^2$	$R2^1$	$R2^0$
1	1000V (750V Max)	x.01	10V	1.1	0	0	1
2	100V	x.01	1V	11	0	1	0
3	10V	x1	10V	1.1	0	1	1
4	1V	x1	1V	11	1	0	0
5	.1V	x1	.1V	110	1	0	1
6	.01V	x1	.01V	1,100	1	1	0

By itself, Model K5 is self-encoding and is entirely manually operated; however, if option S3-1 (see below) is included, the meter may be remotely encoded by means of a suitable external command as described in the specifications for option S3-1.

Option C, added to a K5 plug-in, provides the same number of DC/DC Ratio ranges as are present in the K module, but will not measure voltages as well as ratios.

1-3-3. MODELS K5A AND K6 PLUG-IN MODULES

Inserting Models K5A and K6 plug-in accessory modules into the mainframe provides the instrument with the following multiple DC measurement ranges:

Model	Ranges F.S.	Overranges to
K5A	±1.0000 volt ±10.000 volts ±100.00 volts ±750.00 volts	±1.2000 volts ±12.000 volts ±120.00 volts no overrange
K6	±10.000 millivolts ±100.00 millivolts ±1.0000 volt ±10.000 volts ±100.00 volts ±750.00 volts	±12.000 millivolts ±120.00 millivolts ±1.2000 volts ±12.000 volts ±120.00 volts no overrange

Otherwise Models K5A and K6 are identical to Model K5 described above.

1-3-4. MODELS P1 AND P2 PLUG-IN MODULES

Inserting Models P1 and P2 plug-in accessory modules into the mainframe provides the instrument with the following DC measurement ranges:

Model	Ranges F.S.	Overranges to
P1	±1.0000 volt ±10.000 volts ±100.00 volts ±750.00 volts	±1.2000 volts ±12.000 volts ±120.00 volts no overrange

Model	Ranges F.S.	Overranges to
P2	±10,000 millivolts	±12.000 millivolts
	±100.00 millivolts	±120.00 millivolts
	±1.0000 volt	±1.2000 volts
	±10.000 volts	±12.000 volts
	±100.00 volts	±120.00 volts
	±750.00 volts	no overrange

All of the ranges shown above are manually selectable by means of the panel-mounted pushbuttons, and also can be remotely selected by means of suitable external commands when the input/output option S4-1 is used. Specifications for range selection commands will be found under S4-1 option. Connector pin designations are included in Section II, Paragraph 2-9.

Both P1 and P2 have a manual switch to select function whenever the ratio option "C" is included. The function selector is a good-quality slide switch mounted on the top of the inside panel of the plug-in. With option "C", Models P1 and P2 function as voltmeters or ratiometers, according to the setting of the manual function selector switch. Except for the number of available ranges, options P1 and P2 are identical in design and operation.

If it is expected that the instrument will later be remotely programmed, P1 or P2 should be installed initially.

1-3-5. MODEL P1A AND P2A PLUG-IN MODULES

Models P1A and P2A will provide the same facilities as P1 and P2, but in addition, they will accept the factory-installed Autorange Board, option A. P1A and P2A are fitted with an additional "AUTORANGE" pushbutton which when pressed, places the instrument into the fully autoranging mode. If it is expected that the instrument will later be remotely programmed, or will require autorange, P1A or P2A should be installed initially.

1-3-5-1. MODEL A AUTORANGE BOARD

Model A Autorange board is a factory-installed option for use with Models P1A and P2A. It provides full autoranging on all of the meter's measurement ranges.

1-3-6. MODEL B — SELF CHECK OPTION

Model B Self Check option provides a self check of the voltmeter by causing it to measure the voltage of the internal reference. A calibration log of such checks is recorded on the calibration panel decal. When the button, located on the calibration panel, is pressed, the voltage indicated by the meter should be within 1 digit of the recorded value, showing that all elements of the meter are functioning correctly. If a discrepancy greater than 1 digit occurs, meter requires calibration. (See Section V on calibration.)

1-3-7. MODEL C — DC/DC RATIO MODE OPTION

The DC/DC Ratio option can be used with either Type K or P, but when used with Type K, the combination instrument functions as a ratiometer only, without voltage measurement ranges. When used with multiple-range Models, such as K5 or P1, the Model C provides as many ratio ranges as there are voltage ranges. When used with Models P1 or P2, the function selector switch will select voltage measurements or ratio measurements. Normal input connections for ratio measurements are the same as for the DC voltage measurements but with the addition of a BLUE banana jack on the rear panel to accept an additional cable carrying the POSITIVE reference input voltage. An outstanding feature of the Model C is its ability to measure widely different ratios using a reference voltage from 8 to 12 volts without losing its ±.01% resolution. The function selector switch is located on the top of the inside panel of the plug-in module.

Standard C option is a 3-wire device; signal low and reference low terminals being common. If the polarity of the signal changes with respect to the reference, indicated polarity of the signal also changes. THE DECIMAL POINT IS PLACED SO THAT THE READING EQUALS THE RATIO TIMES TEN. The following ratio chart shows the ratio ranges available.

1-3-8. MODEL E — HIGH SPEED OPTION (DATA SYSTEM VERSION)

Inclusion of this option increases the encoding speed of the instrument to 50 milliseconds while maintaining accuracy within ±.01% of standard instrument specifications. The

RATIO CHART

Ratio Range	DC Range	Ratio Readings*	Actual Ratios
0.001:1	10MV	MV ±0.000 to MV ±12.000	±0.0000000:1 to ±0.0012000:1
0.01:1	100MV	MV ±00.00 to MV ±120.00	±0.000000:1 to ±0.012000:1
0.1:1	1V	±.0000 to ±1.2000	±0.00000:1 to ±0.12000:1
1:1	10V	±0.000 to ±12.000	±0.0000:1 to ±1.2000:1
10:1	100V	±00.00 to ±120.00	±0.000:1 to ±12.000:1
100:1	750V	±000.0 to ±750.0	±00.00:1 to ±75.00:1

*The ratio symbol "R" is displayed with each reading.

response time includes all delays to be expected in a typical data system, and allows external encoding of the meter at up to 20 readings per second. Built-in data storage register effectively doubles the overall system rates by permitting time-sharing.

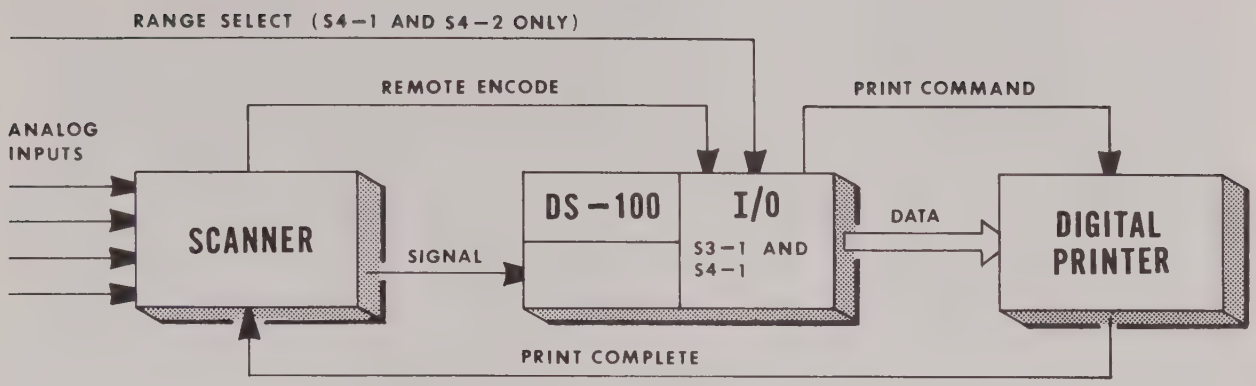
1-3-9. MODELS S3-1, S4-1 and S4-2 INPUT/OUTPUT INTERFACE CARDS

Models S3-1 and S4-1 are input/output modules which enable the Doric DS-100 Series to interface with and be controlled by external logic elements. They each consist of a plug-in card, as shown in Figure 1-2, with the necessary connectors for logic inputs and outputs, and transistor switches for operating printers, etc.

Model S4-2 has no electrical data outputs, but allows the meter to be programmed remotely from a suitable external source. Inputs consist of programming commands which place the meter into the required range, and of encode commands which remotely encode the meter. Pin connections are shown in Section II Paragraph 2-8. When using any of the Input/Output modules, the SAMPLE RATE control on the mainframe is set to HOLD, enabling the meter to respond to remote encode commands only.

1-3-9-1. ELECTRICAL INPUTS

Adding S3-1, S4-1 and S4-2 to the DS-100 allows the meter to accept AC-coupled remote encode commands from an external source. With S4-1 and S4-2 there is the extra capability of accepting remote positive true range select commands in the form of voltage levels. A positive true logic level may be applied to one of six range lines. The range number indicates the number of places to the left the decimal point is to be placed.



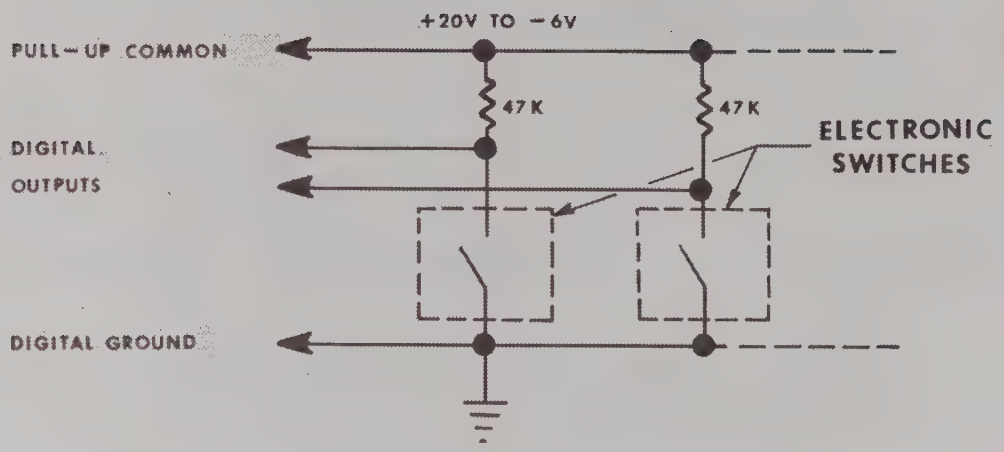
DS-100 WITH S3-1 AND S4-1 SYSTEMS APPLICATION fig. 1.3

Range 1 is the 750.0V Range, Range 2 is the 100.00V Range, etc. The false level is from -20V to +.5V. The true level is +4V to +20V. The input impedance is 100K or greater. Overvoltage protection to ±100V is provided. The input logic levels may normally be controlled by logic types which have 4V or greater output swing, such as DTL and TTL integrated circuits.

1-3-9-2 ELECTRICAL OUTPUTS

By using the S3-1 or S4-1, the digital readout of the meter is converted into 8-4-2-1 "closure false" digital data outputs.

The DS-100 Microvoltmeter uses a unique solid state closure output system shown in Figure 1.4. The magnitude, polarity and range of the measurement are represented by 23 bits of information. Each of these bits is available at the rear connector J6, in the form of an electronic switch closure to digital ground. All the switch closures are connected to a common pull-up line by 47K pull-up resistors. This pull-up common is available on J6, Pin X. By applying a voltage between -6V and +20V to this line, the closures may be converted to any desired voltage levels. All information is presented in the 8-4-2-1 BCD format and is available in closure false (standard) or closure true (optional). The electronic switches are essentially pure resistors when "on" with a resistance less than 200Ω for load currents up to ±2 MA. The "off" resistance is greater than 100 megohms.



ELECTRONIC SWITCHES − OUTPUTS fig 1.4

The output circuits are also compatible with the 830 or 930 Series DTL I. C. logic and type SN5400, SN7400 or 9000 Series TTL logic or other logics having less than 2. 0MA input "0" load current. For use with I. C. logic, the pull up common is tied to the +5V I. C. supply.

The complete isolation of the electrical outputs from the meter circuitry ensures that the overall common mode rejection ratio is maintained in spite of a common mode voltage on the signal lines of 30V peak-to-peak. For input connections, refer to Section II. Specifications of the commands and data logic levels are included in the specifications section.

For external connections to S3-1, S4-1 and S4-2, refer to Section II Paragraph 2-8 and 2-9. For connections when using a digital output device, refer to Section II Paragraph 2-7. Schematic No. 100-636 shows the circuit arrangement of the I/O Board using "closure true" outputs, and is complete with pin connections and component designators.

1-3-10. MODEL W. RACK MOUNTING ADAPTER

The rack mounting adapter accepts one voltmeter and a filler panel or two voltmeters. It has mounting ears, and can be mounted in a standard 19" rack, as illustrated. For assembly details refer to Section II.

1-3-11. MODEL X. EXTENDER BOARD

This extender board enables either the mainframe or the plug-in module to be operated at some distance forward from their normal positions, thus facilitating service.

1-3-12. MODEL Y. REAR SIGNAL INPUTS

Inclusion of this option provides a duplicate set of signal input plugs on the rear rail. These are in parallel with the input plugs on the front panel, and are used to convey the signal to the meter when operating in a system rack.

1-3-13. MODEL Z. LOW THERMAL INPUT CORD SET

Special soldering techniques render this input lead less susceptible to thermoelectric effects, and permit more accurate measurement of low level inputs.

SECTION II

UNPACKING, INSTALLATION, REPACKING AND CONNECTING UP

2-1. GENERAL

Retain all packing materials in case the instrument must be returned to Doric; repacking instructions are also provided in this section.

2-2. RECEIVING INSPECTION

The unopened package should be checked for external damage before it is accepted from the shipping agency. After unpacking, the instrument should be carefully checked for damage, which should be reported to the shipping agency and to Doric.

NOTE

For shipping purposes, the plug-in module is held firmly in place by two shipping screws, Phillips-head 4-40 x 1/2", located just forward of the front feet. These screws should be removed on arrival, and replaced before reshipment (see Figure 2.2).

2-3. INSTALLATION

2-3-1. POWER REQUIREMENTS AND LINE VOLTAGE SETTING

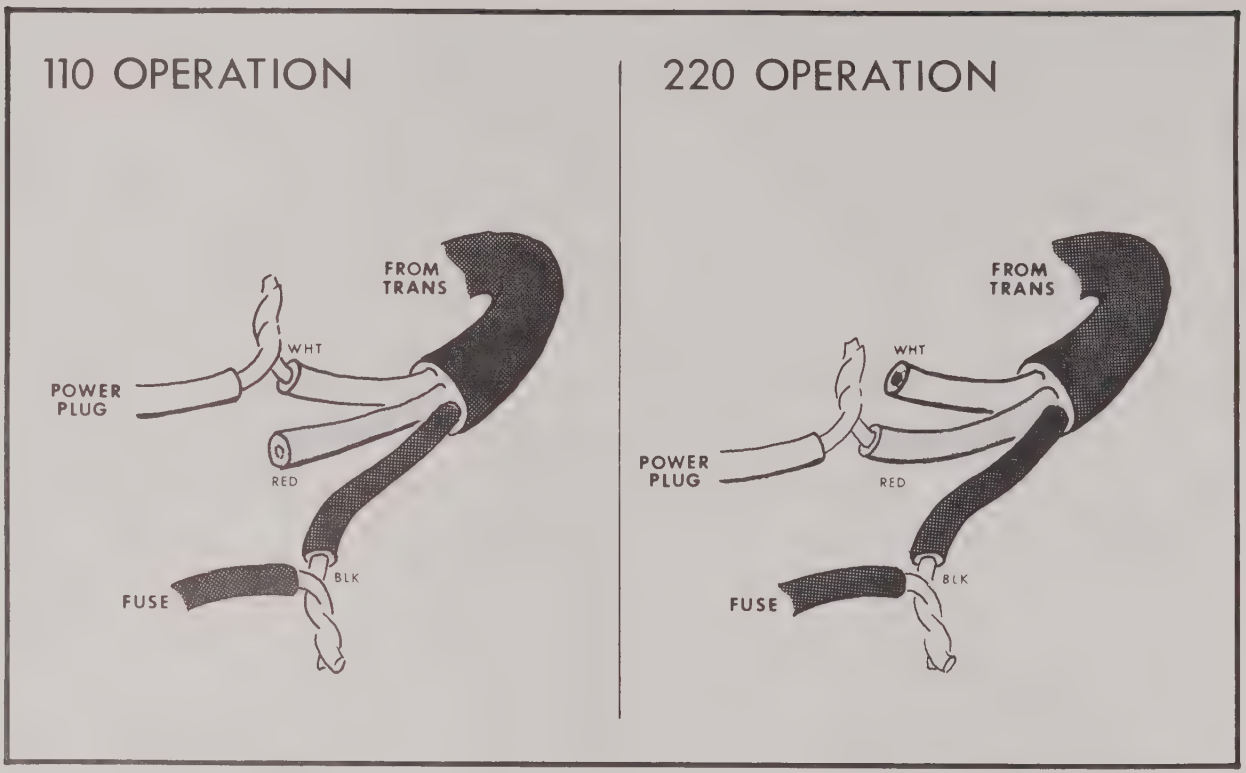
The instrument is normally wired to operate from a 115 volt ±10% AC power source, 50 to 400 Hz, but can also be wired to operate from a 230 volt ±10% AC power source. A .25A slo-blo power fuse is used for 115 volts; a .125A for 230 volts. To change from 115 volts to 230 volts (refer to Figure 2.1):

a. Remove the four screws holding rear panel, slide the top panel out from the rear.

b. Remove the black insulation from the junction of the power cable and the power transformer cable.

c. Break connection between white power wire and white transformer wire, and solder white power wire to previously unused red transformer wire.

d. Re-insulate wires and reassemble the instrument.



LINE VOLTAGE SETTING fig 2.1

2-3-2. BENCH MOUNT INSTRUMENTS

Bench mount instruments have four rubber feet. A folding stand is attached between the two front feet. With stand folded, the instrument lies flat on the work bench. When stand is pulled down, the front of the instrument is raised for easy viewing (Figure 2.2).

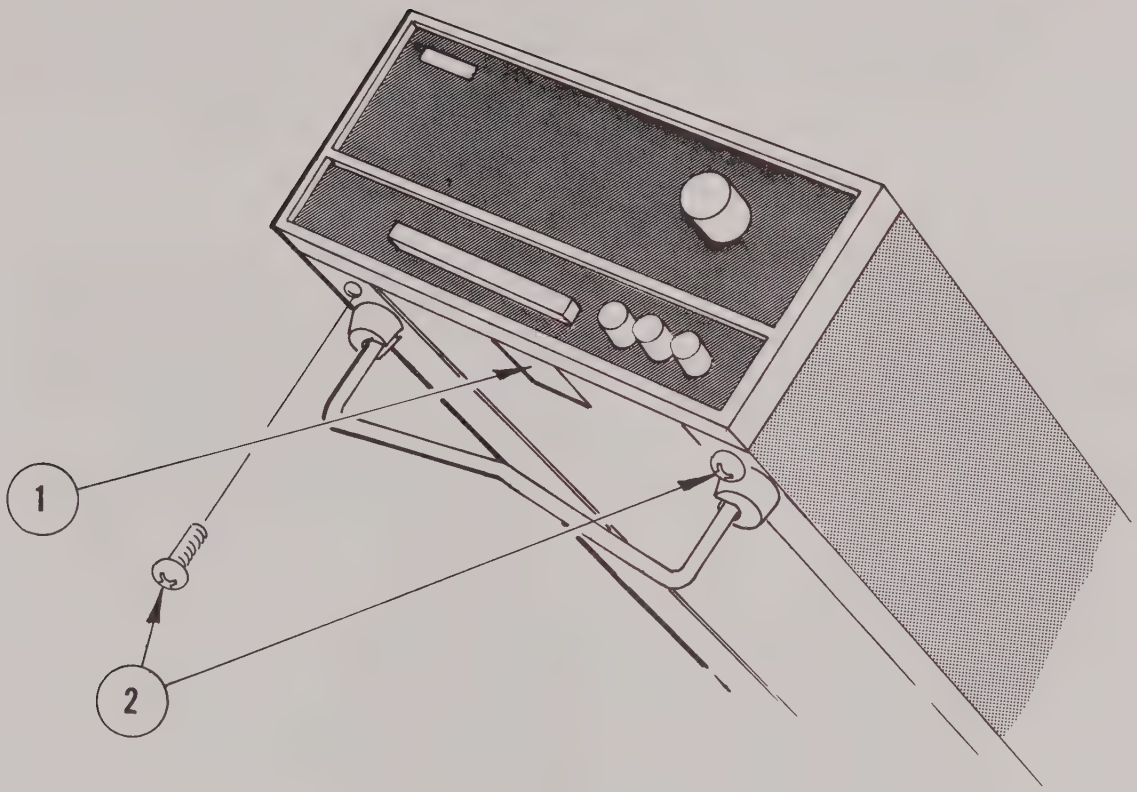
2-3-3. RACK MOUNTING ADAPTER

Option W converts bench mount instruments to rack mount instruments. A filler panel is provided for the vacant space if one voltmeter is installed (Figure 2.3); or two instruments can be mounted side by side, (Figure 2.4). The rack adapter is shipped separate from the basic meter.

To mount instrument in Rack Mounting Adapter:

a. Remove the four feet and folding stand from the bench instrument.

b. Four screws provided are inserted through holes in the front and rear mounting bars and into the holes previously used to secure the four feet. (Do not use the screws that held the feet.)

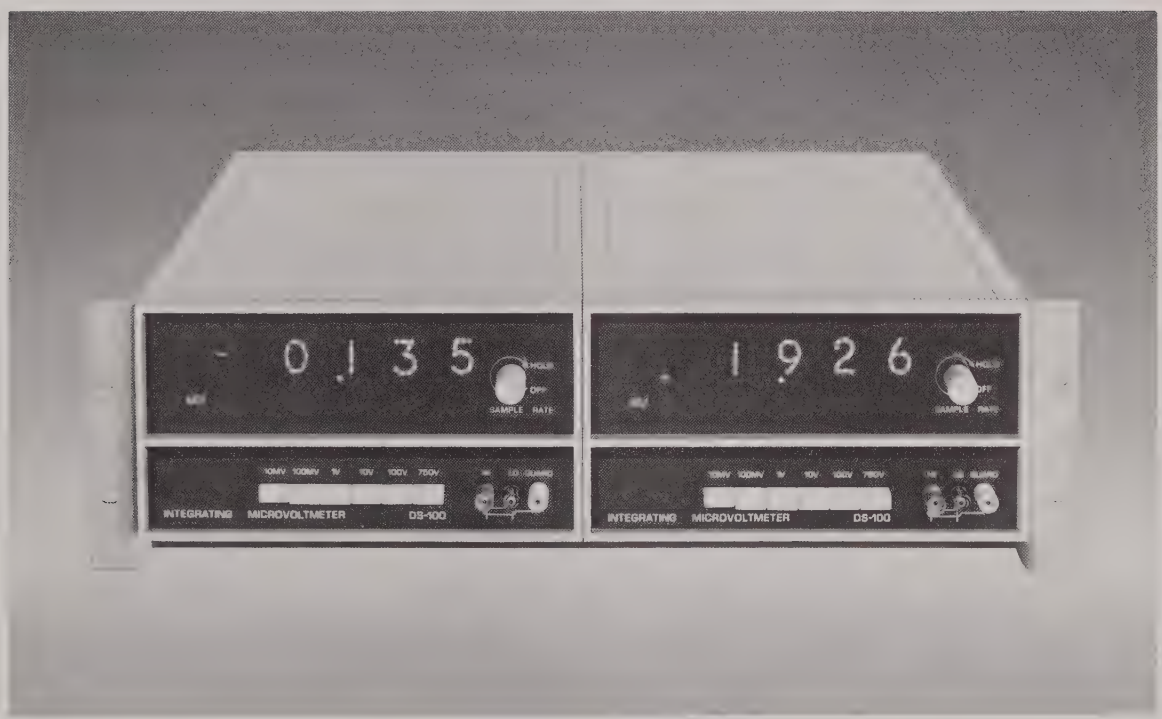


1. LATCH

2. SHIPPING SCREWS

DETAIL OF LATCH, STAND & SHIPPING SCREWS fig 2.2

RACK MOUNT OPTION W - ONE DS-100 MOUNTED fig 2.3



RACK MOUNT OPTION W - TWO DS-100 MOUNTED fig 2.4

c. Use four screws from the adapter kit to secure the filler panel to the front mounting bar.

d. Four screws are used to mount the adapter in a standard 19" equipment rack.

2-4. REPACKING INSTRUCTIONS, ORIGINAL CONTAINER

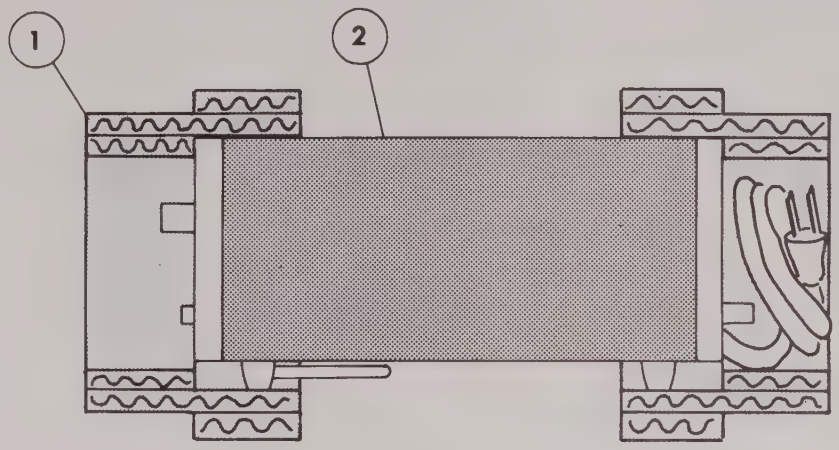
If an instrument must be returned to Doric for any reason, return must be authorized and instrument must be packaged with great care to ensure safe arrival. Procedure is to telephone or write Doric Scientific Corporation requesting authorization to return the instrument to the factory. Ask Doric to send a special shipping carton free of charge if you do not have the carton in which the unit was originally shipped. When authorization is received, pack the instrument in the Doric container as follows (see Figure 2.5):

a. Ensure that the plug-in module is firmly seated and held in place by the spring-latch, then install the two shipping screws, 4-40 x 1/2", in the holes forward of the front feet (Figure 2.2). UNLESS BOTH SHIPPING SCREWS ARE IN PLACE, DAMAGE TO THE INSTRUMENT WILL RESULT.

b. Attach a tag bearing your name, telephone number and extension, indicating the services or repairs needed, or symptoms noted. If out of warranty, enclose a purchase order for required services or repairs needed, or request estimate.

c. Use tape to secure the rectangular cardboard collars around both ends of the instrument; ensure that the collars are fitted around the feet, and protect the panel controls with padding. Place about one inch of padding and a sheet of cardboard at the closed end of the original container and then insert the instrument into the container. Add a sheet of cardboard and sufficient padding at the open end of the container to prevent any movement of the instrument. Seal the open end of your carton with strong shipping tape.

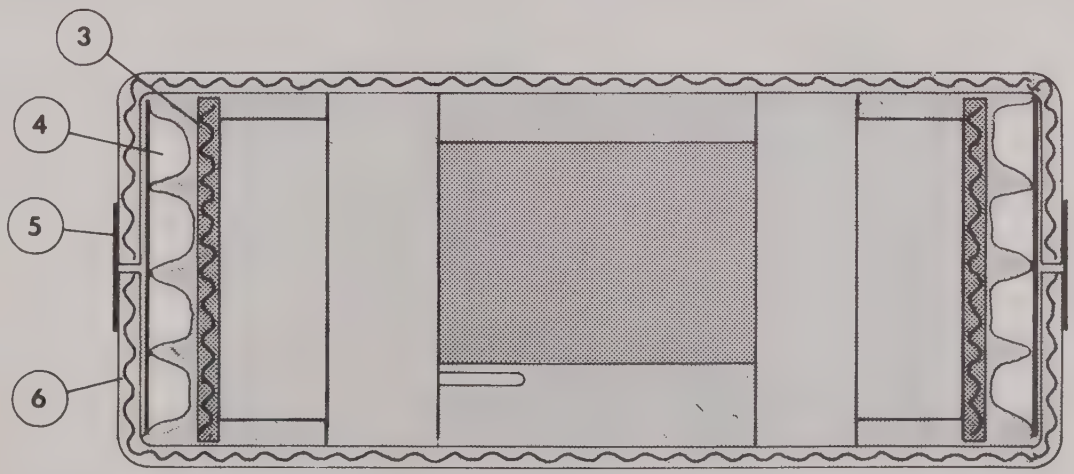
d. Mark the container with your name, and address, and "FRAGILE, DELICATE, INSTRUMENT". Identify the instrument by model and serial number in any



STEP 1

FOR DETAILED INSTRUCTIONS, SEE PARAGRAPH 2-4.

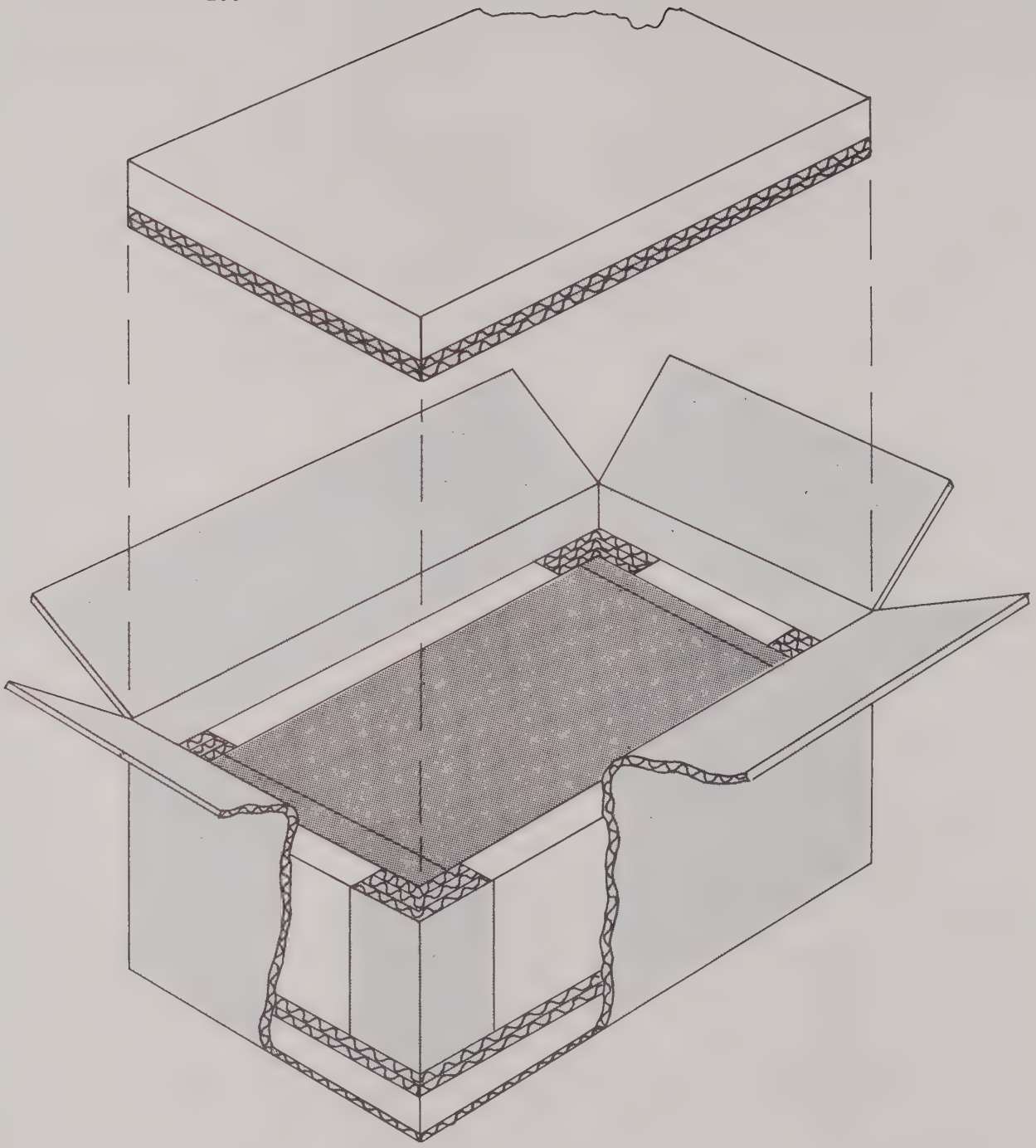
Place rectangular cardboard collars (1) around both ends of the instrument (2), coil power cord as shown above.



STEP 2

Place about 1" of padding (4) and a sheet of cardboard (3) at closed end of container (6). Insert instrument (with collars attached), place second sheet of cardboard at open end of container, add padding, close and seal carton with strong shipping tape (5).

REPACKING INSTRUCTIONS ORIGINAL CONTAINER fig 2.5



If original Doric container is not available, construct and use the shipping case shown above. For detailed instructions of construction of case and packing of instrument, see paragraph 2-4-1.

CONSTRUCTION OF SHIPPING CASE fig 2.6

correspondence with Doric. Serial numbers are located on the bottom of analog plug-in and inside the Main-Frame cavity for the plug-in.

e. Ship the instrument to Doric Scientific Corporation, 7969 Engineer Road, San Diego, California 92111, --- Freight Prepaid.

2-4-1. REPACKING INSTRUCTIONS, NEW CONTAINER

If the original container is not available, and a new container must be made, proceed as follows:

a. Obtain a strong reinforced cardboard carton, of sufficient size to allow at least four inches of empty space between any part of the meter and any part of the carton. Place on bench with opening uppermost and with flaps turned back. See Figure 2.6.

b. Pack at least four inches of resilient padding (polyfoam, bubble-pack, rubberized hair) on bottom of carton, and cover with a rectangle of heavy double corrugated cardboard cut to fit the carton.

c. Wrap meter in plastic or strong paper, and place it centrally on the cardboard rectangle. Cut and insert four sets of corner pads, as shown in the illustration, sufficient to hold meter in a central position during transit. Corner pads are made of thick corrugated cardboard. Fill the four spaces between the corner pads with resilient padding.

d. Cut a second rectangle of heavy double corrugated cardboard to fit the carton and insert above meter.

e. Pack the space above the rectangle and the top of the carton with sufficient resilient padding to fill it to the top. This layer must be at least four inches thick.

f. Close flaps, seal with strong shipping tape, and reinforce all joints in carton, label and ship as outlined above.

2-5. INPUT CONNECTORS — VOLTAGE MEASUREMENTS

Signal inputs are normally led in through Hi, Lo and Guard terminal sockets mounted on the front panel of the plug-in module. Mating connectors are provided. Option No. Y provides an identical set of connectors on the rear rail of the module, in addition to the front inputs. Option Z is a low thermal effect signal input cable, four feet long which mates with the front or rear jacks and includes alligator clips on the outer end.

2-5-1. INPUT CONNECTORS — RATIO MEASUREMENT

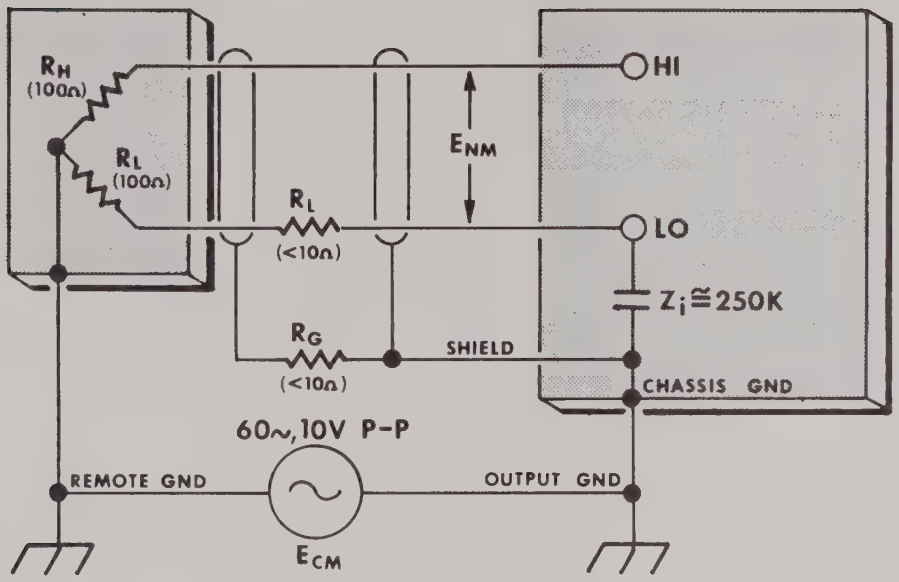
When Option C is included, an additional (blue) banana jack is provided on the rear rail for reference Hi. Signal Lo serves also as a reference Lo. Reference Hi must always be positive relative to reference Lo. The input signal may be of either polarity.

2-6. CONNECTIONS FOR MINIMIZING COMMON MODE NOISE INTERFERENCE

Guarding must be used whenever low level measurements are to be made and a significant (≥10 digits) amount of AC or DC voltage exists between the signal source and DVM chassis ground. The conditions in an unguarded system when such a common mode voltage is present are shown in configuration I, Figure 2.7. The common mode voltage, E_{cm}, causes a large current to flow through the transducer low-side resistance R_L, the signal LO lead resistance, R'_L, and from there through the isolation impedance Z_i to LOCAL GROUND. A voltage drop resulting from the common mode current will appear across R_L and R'_L. This voltage is in series with, and appears as part of the source voltage being measured, and could produce up to 4400 digits of noise (assuming 1μv/digit). To avoid this, one of three guarding systems may be used.

To choose the proper system, the characteristics of the transducer to be used must be considered. Some transducers must be grounded at installation site for safety or mechanical reasons, (e.g., thermocouples or strain gages bonded to a missile airframe). In this case, configuration II must be used. Note that the guarded isolation impedance, Z_{iG}, will be much higher than Z_i shown in configuration I. This is because the common mode currents are carried from remote ground by the guard, R_G, and drive the metalwork surrounding the DVM measurement section to a potential almost equalling E_{cm}.

I UNGUARDED DVM

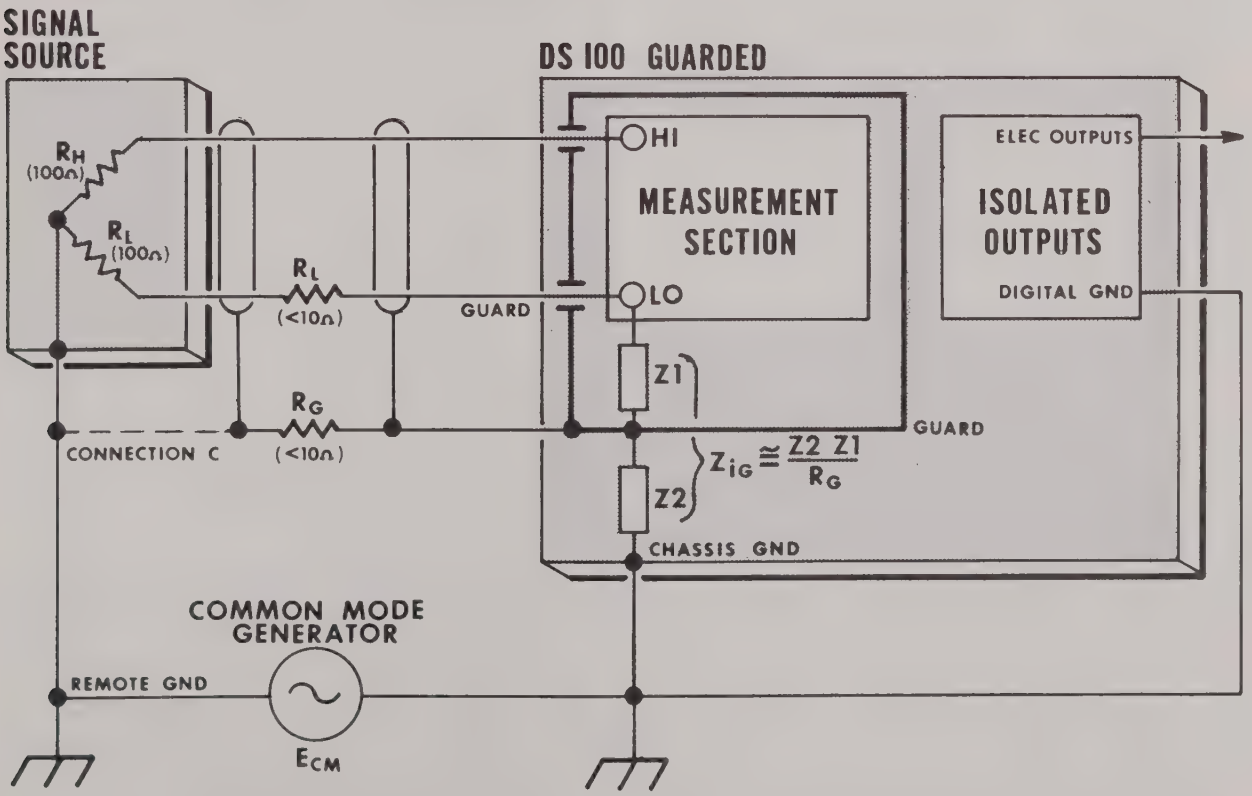


$$E_{NM} \cong \frac{E_{CM}\ R_L}{Z_i}$$

$$= \frac{10 \times 10^2}{2.5 \times 10^5} = 4 \times 10^{-3}$$

$$= 4MV\ P\text{-}P$$

II REMOTELY GROUNDED TRANSDUCER



GUARDING fig 2.7

Thus very little current flows in R_L and R'_L because the voltage drop across Z1 is very small. The key point is to make connection C at the remote site so that guard is at the remote ground potential most closely associated with the transducer being measured.

With truly floating transducers (thermocouples, batteries, etc.), Figure 2.8 configuration III may be used. It is assumed that transducer isolation impedance, Z_{ti}, is very high (higher than Z2). In this case, connection C may be made at the local (DVM) ground. This simplifies scanning systems by requiring only signal HI and LO lines to be switched rather than HI, LO and guard as in configurations II and IV. Note that guard is attached to signal LO at the remote site. The resulting CMRR will approximate that of II.

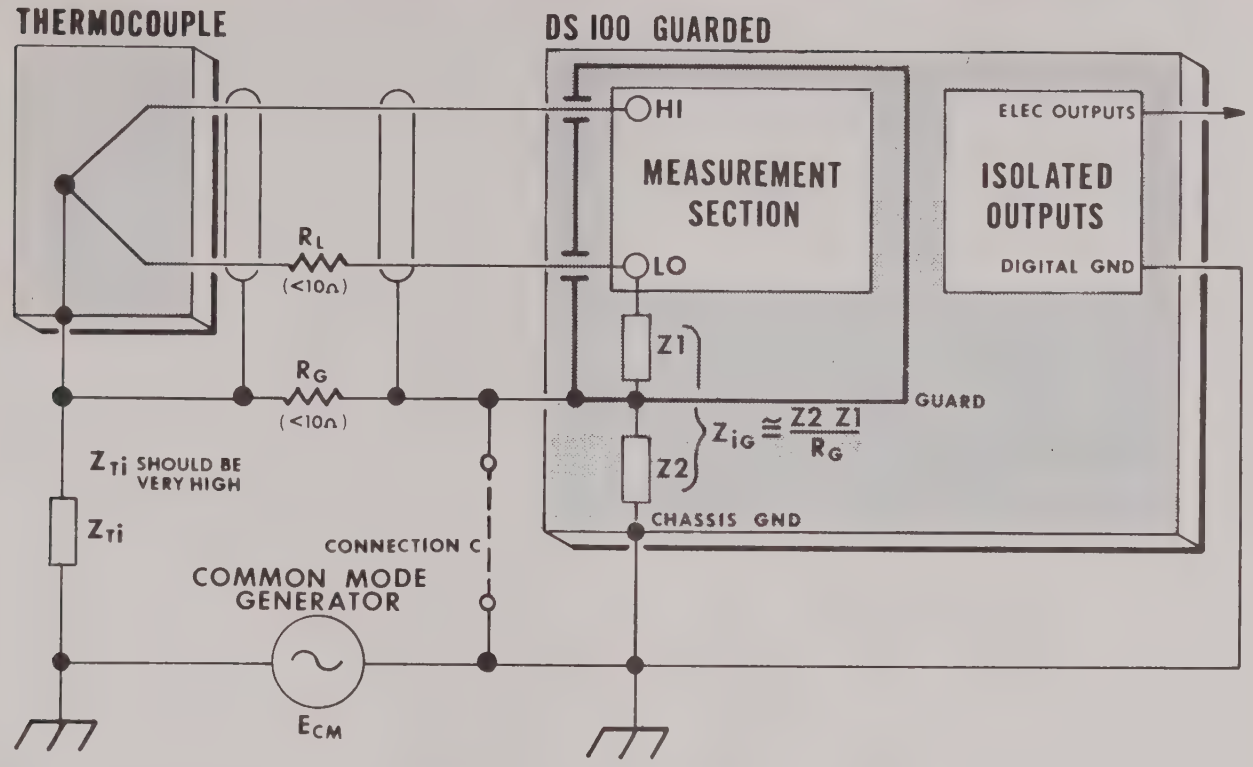
A superior technique for any kind of floating transducer is shown in Figure 2.8 configuration IV. Running an extra wire from LOCAL (DVM) ground to the low side of the remote transducer virtually shorts out the common mode source, and greatly reduces the source common mode voltage, E_{cms}. This will result in a large increase in the effective common mode rejection. When configuration IV cannot be used, quasi-floating transducers (DC power supply excited transducers, e.g., bridges, pots) generally work best with configuration II. This requires connecting one side of the power supply to remote earth ground. It should be remembered that IN ALL CASES THE TRANSDUCER OR METER MUST BE GROUNDED SOMEWHERE, BUT ONLY AT ONE POINT. A completely floating transducer-meter combination will allow uncontrolled common mode voltages to develop which are potentially dangerous and will adversely affect measurement accuracy.

For most bench applications, meters may be operated with the signal LO attached to Guard at the front panel.

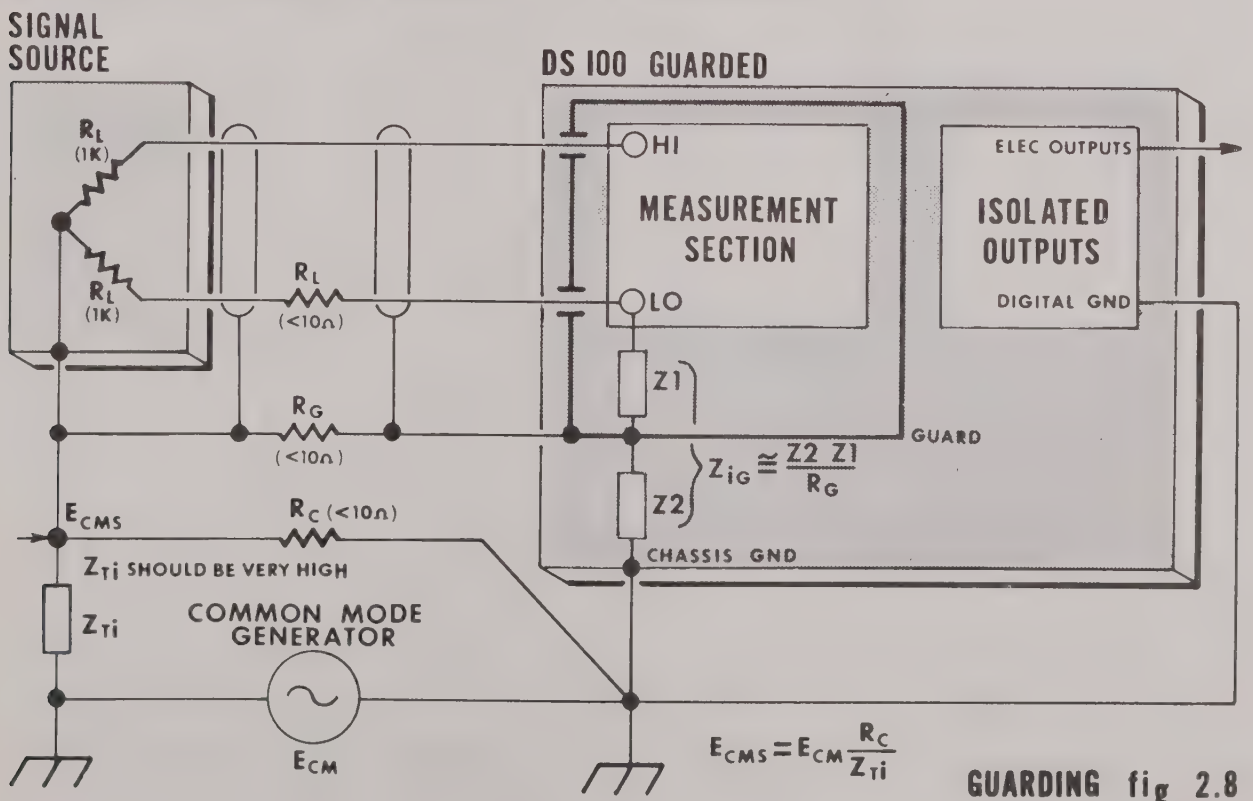
2-7. CONNECTIONS WHEN USING DIGITAL OUTPUT DEVICE

The DS-100 equipped with the S3-1, S4-1 or S4-2 I/O card will meet the stated common mode rejection ratio specifications for up to 24V p-p (±12V) common mode voltage. Overvoltage protection to 300V p-p is provided. To ensure that the common mode voltage is within the specified limits, the digital ground (J6 Pin C) should return to

III FLOATING TRANSDUCER, LOCALLY GROUNDED



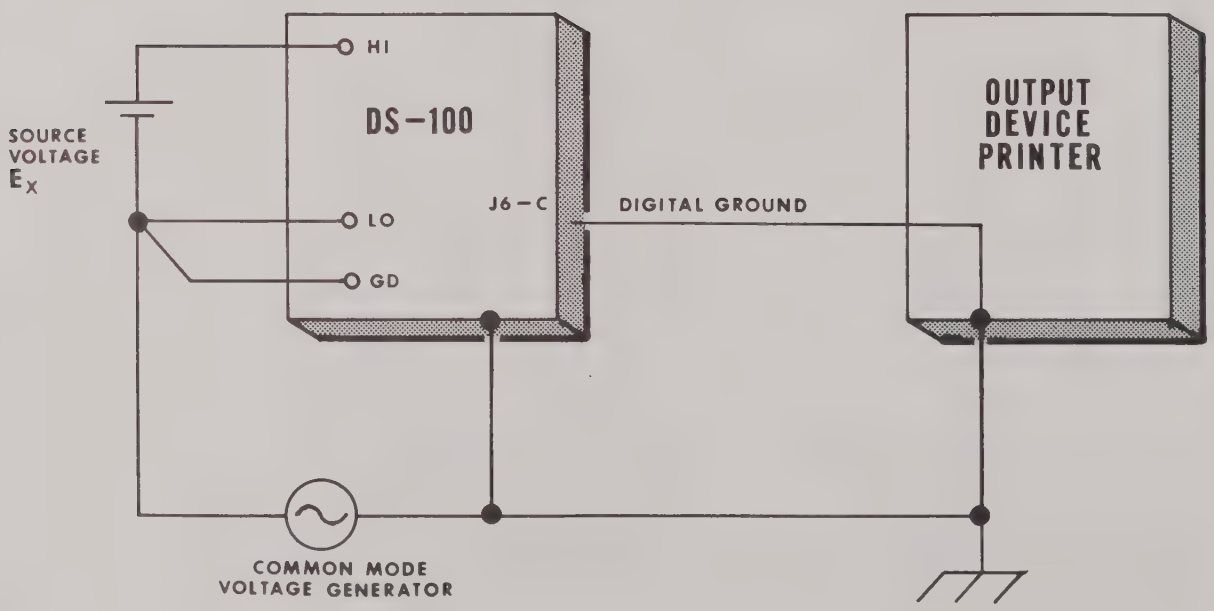
IV FLOATING TRANSDUCER, IMPROVED LOCAL GROUNDING



GUARDING fig 2.8

chassis ground when the I/O connector is used. This return path may go through the output device if desired. As shown in the discussion in Paragraph 2-6, the signal source will ultimately also return to chassis ground, either directly or through the common mode generator. See Figure 2-9.

The pin connections for mating the DS-100 to the Hewlett-Packard M59-562A or HO-59-5050A digital printer are shown in the list following. A cable made to this configuration will mate the DS-100 to either the H-P M59-562A or the H-P HO-59-5050A. These printers with the prefix numbers shown supply pull-up voltages compatible with their logic.



CONNECTION TO DIGITAL OUTPUT DEVICE, SHOWING COMMON MODE PATH fig. 2.9

PIN CONNECTIONS

DS-100 CONNECTOR J6 TOP SIDE	HP HO-59-5050A Conn. A1J1 or HP M59-562A Conn. J101	DS-100 CONNECTOR J6 BOTTOM SIDE	HP HO-59-5050A Conn. A1J1 or HP M59-562A Conn. J101
A		1	23
B	27	2	14
C	50	3	13
D	12	4	
E	37	5	11
F	36	6	
H	38	7	
J		8	9
K		9	35
L		10	34
M		11	10
N		12	21
P		13	
R		14	7
S	25	15	33
T	24	16	32
U		17	8
V		18	
W		19	
X	39	20	
Y		21	26
Z		22	5
a		23	31
b		24	30
c		25	6
d		26	1
e		27	2
f		28	3
h		29	29
j		30	28
k		31	4

2-8. EXTERNAL CONNECTIONS WHEN USING S3-1 AND S4-1.

INPUT/OUTPUT CONNECTION CHART

CONNECTOR J6 TOP SIDE	CONNECTOR J6 BOTTOM SIDE
(p) k. Range 5 select	31. 2_0
(p) j. Range 6 select	30. 4_0
(p) h. Range 4 select	29. 8_0
(p) f. Range 3 select	28. 1_0
(p) e. Range 2 select	27. Output Range 2^1
(p) d. Range 1 select	26. Output Range 2^0
c. Blank	25. 2_1
b. Function 1 select	24. 4_1
a. Function 2 select	23. 8_1
Z. Blank	22. 1_1
Y. Blank	21. Output Range 2^2
X. Pull-up Common	20. Blank
W. -24V	19. Blank
V. Blank	18. Blank
U. Blank	17. 2_2
T. LO Ref. *	16. 4_2
S. HI Ref. *	15. 8_2
R. Function 3 select	14. 1_2
P. Decimal 1 select	13. Output Function 2^1
N. Decimal 2 select	12. Pull-up Regulator Input *
M. Decimal 3 select	11. 2_3
L. Decimal 4 select	10. 4_3
K. Blank	9. 8_3
J. Blank	8. 1_3
(p) H. Digital Ground	7. Output Function 2^0
(p) F. Digital Ground	(p) 6. Sample command
(p) E. Digital Ground	5. 1_4
(p) D. Digital Ground	4. Overload
(p) C. Digital Ground	3. - polarity
(p) B. Digital Ground	2. NOT Overload *
A. Analog Ground	(1) 1. Sample complete (print command)

NOTES:

1. The connector is Winchester PQD31SO with solder terminals.
2. The notation on the magnitude outputs are as shown:
   2_0 equals 2×10^0 equals 2; or 8_2 equals 8×10^2 equals 800.

*3. For use with HP562A or 5050A Printers.

4. For pins marked (p), see Section 2-9.

2-9. EXTERNAL CONNECTIONS WHEN USING P OPTIONS WITH S4-2

When programming options are used with S4-2, which has no electrical outputs, none of the digital data pins are connected. Only those pins marked (p) on the connection list given in paragraph 2-8 are used in this instance.

SECTION III

SPECIFICATIONS

3-1. DC VOLTMETER SPECIFICATIONS

DC Ranges: 10MV, 100MV, 1V, 10V, 100V, and 750V are standard full scale ranges available. Instrument is capable of overranging to 120% of all full scale ranges, except 750V range; accuracy specifications also apply to overrange.

Accuracy: 24 hours; +23°C ±1°C

- 10MV range: ±0.02% RDG. ±0.01% FS. ±2μV
- 100MV, 1V, and 10V ranges: ±0.01% RDG. ±0.01% FS
- 100V and 750V ranges: ±0.01% RDG. ±0.02% FS

Sensitivity and Repeatability:

Range	Sensitivity	Repeatability
10MV	1 μV	±2 μV
100MV	10 μV	±10 μV
1V	100 μV	±100 μV
10V	1MV	±1MV
100V	10MV	±10MV
750V	100MV	±100MV

Temperature Effects: +10°C to +40°C

- 10MV range: 0.005% RDG/°C ±0.5 μV/°C
- 100MV range: 0.003% RDG/°C ±0.5 μV/°C
- 1V to 750V ranges: 0.003% RDG/°C

Calibration Stability: Meter will stay within ±0.01% RDG for 30 days; ±0.03% RDG for 6 months from date of last calibration.

Auto-Zero:	Automatic zero drift correction feature applies to all measurement plug-ins.
Input Circuit:	Guarded, floating, differential input.
Input Impedance:	1000 megohms on 10MV, 100MV, 1V, and 10V ranges; 10 megohms on 100V and 750V ranges. Impedance is constant at all times, during and between encodings.
Common Mode Rejection:	120 db minimum at all frequencies with 100 ohms unbalance; effective CMR increases at 40 db/decade (12 db/octave) above 59 Hz.
Maximum Common Mode Voltage:	250 volts DC or peak AC. (Guard to Chassis)
Maximum "LO" to Guard Voltage:	50 volts DC
Normal Mode Rejection:	50 db minimum at 60 Hz (±.15%) increasing at 60 db/decade (18 db/octave) from 30 Hz on 10MV, 100MV, 1V, and 10V ranges; 45 db at 60 Hz on 100V and 750V ranges increasing at 40 db per decade. Integrator pole breaks at 3 Hz rising at 6 db per octave to 30 Hz.
Speed:	500 ms/reading (to 0.01%) all ranges, adjustable to 10 seconds/reading by panel control. See Option E for higher speeds.
Internal Reference:	Temperature compensated zener, typically 6 ppm/℃.
Overload Protection:	100V continuous on DC voltage ranges up through 10V without damage; 750V without damage on 100V and 750V ranges.
Polarity:	Automatic polarity determination, with visual and electrical outputs.

3-2. DC/DC RATIOMETER SPECIFICATIONS

These specifications apply to instruments with Option C. Type P plug-in modules with Option C are capable of providing both voltage and ratio measurements; type K plug-in modules with Option C are capable of providing only ratio measurements.

Ratio Ranges:	Signal Input:External Reference 0.001:1; 0.01:1, 0.1:1, 1:1, 10:1, and 100:1 are standard ratio ranges available that correspond to the 10MV, 100MV, 1V, 10V, 100V and 750V DC voltage ranges, respectively.
Accuracy:	±0.01% RDG. ±0.01% FS with 8 to 12 volt reference, additive to DC voltage specification accuracies.
External Reference:	Any positive DC from 8 volts through 12 volts without loss of four digit (0.01%) resolution. Higher or lower reference inputs available on order. Positive or negative DC signal inputs may be used.
Reference Input Impedance:	10 megohms or greater
Speed:	Same as DC voltmeters.

3-3. HIGH SPEED MEASUREMENT SPECIFICATIONS

These specifications apply to instruments with Option E.

Response Time:	50 ms to within 0.01%, includes all settling delays and measurement period; allows external encoding rates up to 20 readings per second; built-in storage register for time-sharing effectively doubles overall system rates attainable.

Integration Period:	16-2/3 ms, crystal controlled.
Common Mode Rejection:	Greater than 120 db at any frequency, with 100 ohms unbalance in "HI" lead.
Normal Mode Rejection:	Infinite rejection cusps at 60 Hz and multiples thereof, increasing at 20 db/decade; rejection at 60 Hz (±0.15%) is at least 50 db.
Accuracy:	Add 0.01% FS to standard specifications.
Resolution:	1 part in 12000.

3-4. SPECIFICATIONS FOR I/O UNITS S3-1, S4-1 AND S4-2

3-4-1. ELECTRICAL PROGRAM INPUTS

Sample Command:	A negative going AC coupled edge of 4V to 20V amplitude, 2 microsecond minimum fall time, 50 microseconds minimum duration; dynamic input impedance, 47KΩ. The sample command line must remain quiescent for at least 2 ms prior to negative going edge.
Range Command:	A positive true logic level may be applied to one of six range lines. The range number indicates the number of places to the left the decimal is to be located from the right side of the least significant digit. The false level is from -20V to +.5V. The true level is +4V to +20V. Input impedance is 100K or greater. Overvoltage protection to ±100V is provided.

3-4-2. ELECTRICAL OUTPUTS: CLOSURE FALSE (STANDARD)

BCD Range, Polarity, Magnitude, and Print Command:	Solid state "closure" False, 8-4-2-1 code. Closure off resistance greater than 100 megohms;

on resistance less than 200 ohms at ±2 ma. One side of each closure is on output ground. The other side is connected to a 47K resistor which is attached to a common pull-up line. Any voltage from -6V to +20V may be applied to the pull-up common pin to provide either positive or negative true voltage levels. The print command is a step equal in magnitude and polarity to the pull-up voltage with less than 2μs rise time. Note: CMRR specifications are maintained for any CMV to 24V p-p; overvoltage protection to 300V p-p is provided.

3-4-3. OPTIONS INCLUDE

S3-1, Sample Command, BCD Outputs and Print Command

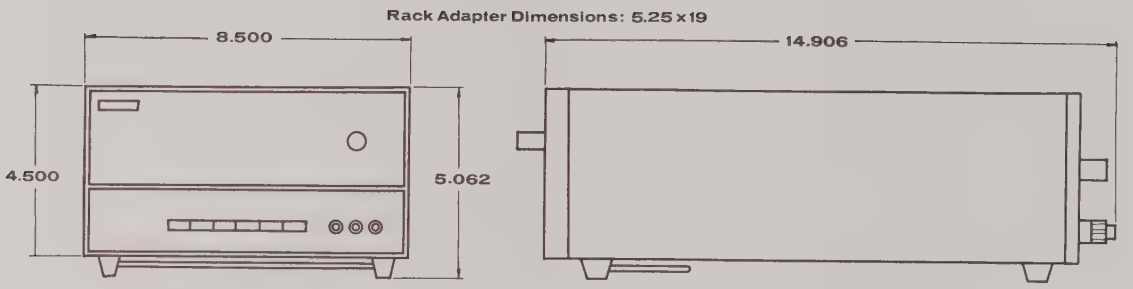
S4-1, Sample Command, BCD Outputs, Range Command, and Print Command

S4-2, Sample Command, Range Command, Print Command, NO Outputs

For pin connections, see section II, paragraphs 2-8 and 2-9.

3-5. GENERAL SPECIFICATIONS

Operating Temperature:	+10°C to +40°C (+50°F to +104°F)
Power Required:	115V ±10%, 50 Hz to 400 Hz, 20 watts maximum; 230V taps provided.
Weight:	12 lbs. net; 17 lbs shipping (approx).
Dimensions - Voltmeter:	See Figure 3-1.
Dimensions - Rack Adapter:	5-1/4" x 19" wide, accepts one or two voltmeters.



OUTLINE DIMENSIONS OF VOLTMETER fig 3.1

SECTION IV

THEORY OF OPERATION

4-1. INTRODUCTION

The Model DS-100 Integrating Digital Microvoltmeter measures DC voltages by a dual-slope integration method, which is much enhanced by the introduction of the unique auto-zero feature. *

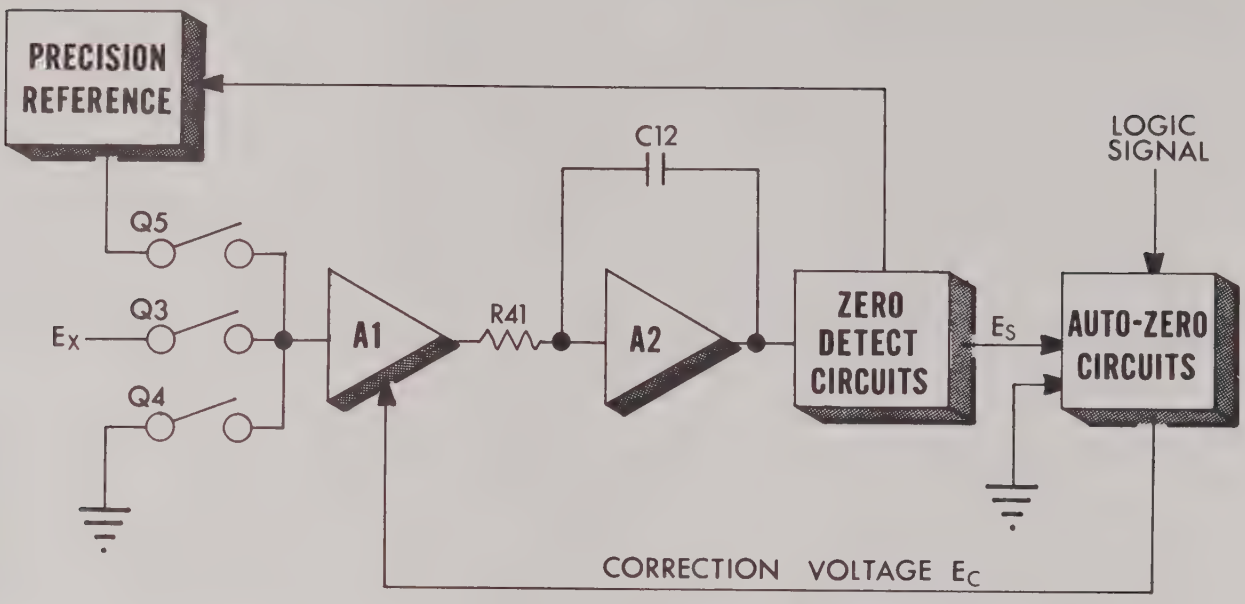
During encoding of a voltage signal, the analog input of the meter is connected to the DC signal voltage (E_X) for approximately 100 ms. During this fixed time, t_1, the integrating capacitor C12 charges at a rate proportional to the DC signal voltage. (See Figures 4.1 and 4.2.) At the end of this fixed integration time, the input of the meter is disconnected from the DC signal and is connected to a precision reference voltage with a polarity opposing that of the DC input, causing the integrating capacitor, C12 to discharge toward ground potential at a fixed rate. The discharge time t_2 required to reach ground potential is proportional both to the reference voltage and to the voltage peak, (E_P) reached by the capacitor during the fixed integration time, t_1. Figure 4.2 shows that time t_2 is directly proportional to E_X and independent of variable factors such as R41, C12 time constant, clock frequency, A1 amplifier gain, and amplifier offsets. To display E_X digitally, fixed-interval clock pulses are counted in a display counter during the discharge time t_2. The count that is accumulated is directly proportional to the input signal E_X.

4-1-1. AUTO-ZERO

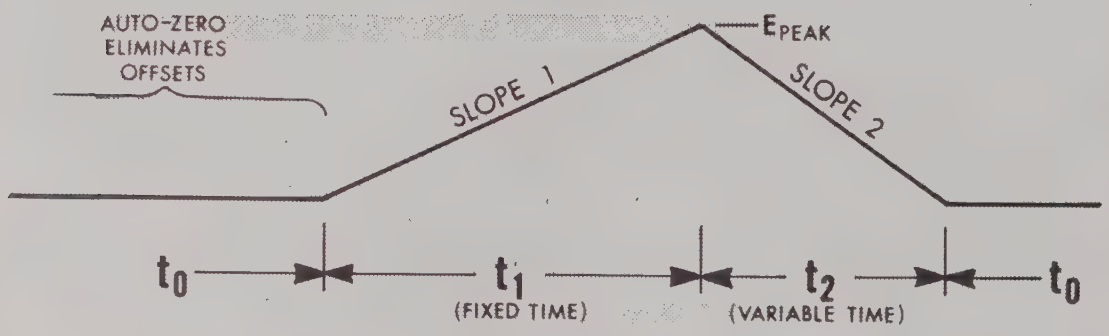
Between encodings the instrument disconnects itself from the signal input voltage E_X, and shorts its own input, (see Figure 4.1). At this time the auto-zero circuit measures the existing offset in the buffer amplifier, A1 integrator amplifier, A2, and zero crossing amplifier. At the beginning of the next encoding, the auto-zero circuit stores the required voltage to cancel the sum of the offsets in these amplifiers.

Between encodings, Q3 and Q5 are open, Q4 is closed, connecting A1's input to ground. Note that DC amplifiers A1, A2 and the zero detection circuits are in series. Any

* Patent Pending



SIMPLIFIED DIAGRAM OF ANALOG CIRCUITS fig 4.1



DUAL SLOPE TIMING DIAGRAM fig 4.2

$$\text{Volts/sec of slope 1} = \frac{E_x A_1}{R_{41} C_{12}}$$

$$\text{Volts/sec of slope 2} = \frac{E_R A_1}{R_{41} C_{12}}$$

$$E_{PEAK} = t_1 \times V/S = t_1 \times \frac{E_x A_1}{R_{41} C_{12}}$$

$$E_{PEAK} = t_2 \times V/S = t_2 \times \frac{E_R A_1}{R_{41} C_{12}}$$

$$t_2 = \frac{E_x A_1 R_{41} C_{12} t_1}{E_R A_1 R_{41} C_{12}} = \frac{E_x t_1}{E_R}$$

$$t_1 = \frac{N}{f_{clk}} \qquad t_2 = \frac{\text{READOUT}}{f_{clk}}$$

$$\frac{\text{READOUT}}{f_{clk}} = \frac{E_x N/f_{clk}}{E_R}$$

$$\text{READOUT} = \frac{E_x N}{E_R}$$

offsets or slow drift occurring in A1 are amplified in A2 and the zero correcting circuits, and fed to the auto-zero. Similarly, the drift of A2 is amplified in the zero detection circuits and fed to the zuto-zero. E_s is the amplified sum of all the offsets occurring in A1, A2, and the zero detection circuits. The auto-zero compares E_s to ground, feeding back a correction voltage E_c to A1 to force E_s to equal zero volts. As long as the operation continues, the output of A2 cannot drift off zero.

4-1-2. MEASUREMENT CYCLE

When the measurement cycle starts, Q4 opens and Q3 closes, applying E_X to A1. Note that if E_X = 0V, the input voltage to A1 has not changed. As a result, A2's output will not move from zero volts and this will yield a perfect zero reading.

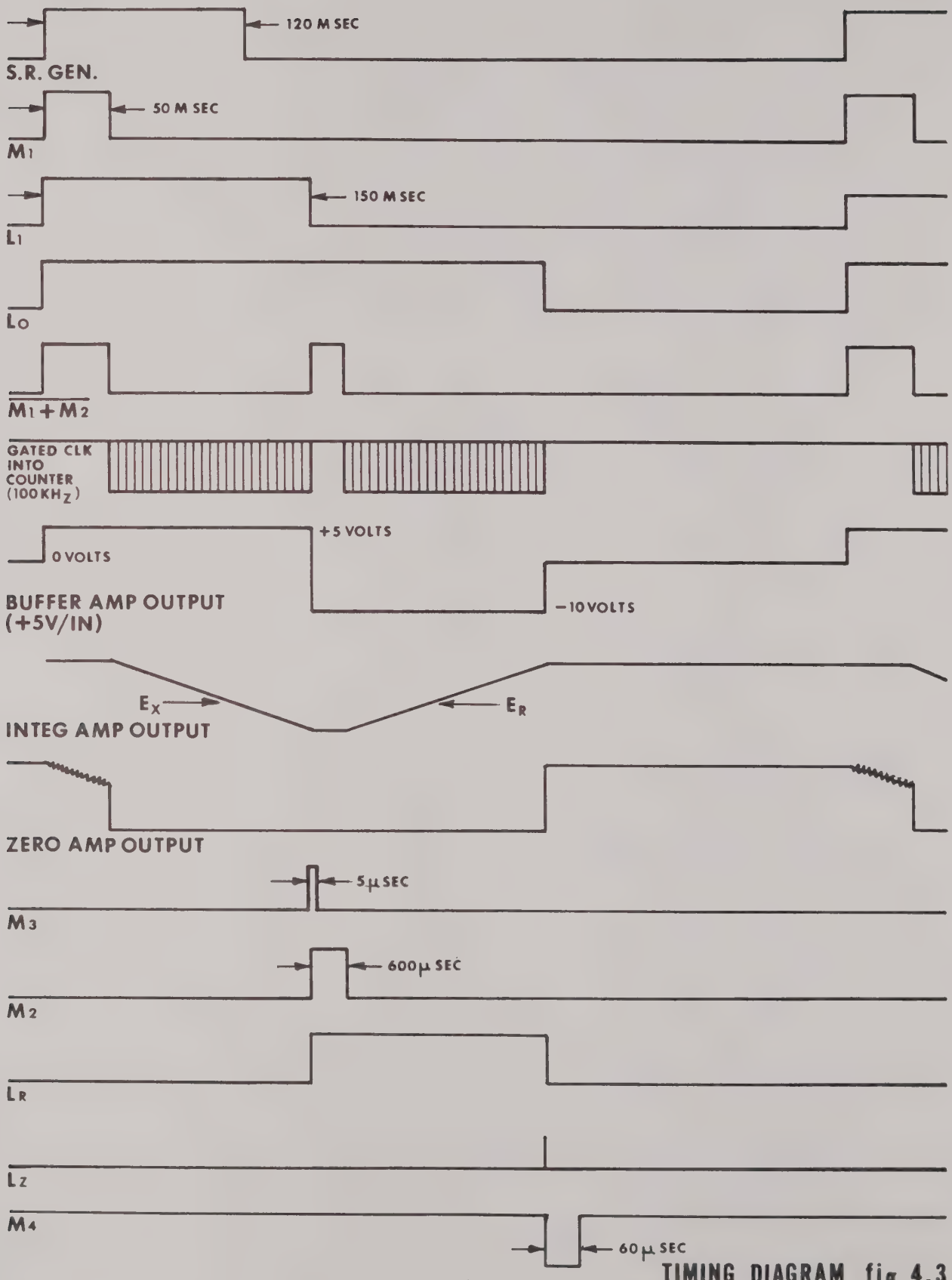
A1, in turn, applies the amplified E_X to the integrating amplifier A2. At the time that Q3 closes, a counter starts to count up from zero to 10,000 to provide the fixed time base, t_1. When the 10,000 count is reached, Q3 is opened and Q5 is closed to either $+E_R$ or $-E_R$ as required to make the output of A2 slew toward ground. As Q5 closes, the counter is reset to zero and again counts up from zero. When the charge on C12 is reduced to zero volts, the counting is stopped and the number accumulated in the counter is displayed on the readout.

4-2. SYSTEM THEORY

4-2-1. SEQUENCE OF OPERATIONS

Refer to Figure 4.3. (timing diagram) and the functional block diagram #100-640 or Schematics #100-628 and #100-625. Voltmeter operations occur in the following sequence:

a. Before a new measurement cycle is started, the readout displays the value obtained from the previous cycle, which is stored in the DATA STORAGE REGISTER. Q4 and Q3 are on and the auto-zero circuit is correcting A1 so that the first stage of the zero Schmitt trigger circuit is half way between its true and false values. Note that L_o, L_1, and L_R are in their false state between encodings.



TIMING DIAGRAM fig 4.3

b. The sample rate generator applies a positive pulse to the input of M_1 to start a series of events which precede a measurement. These pulses are produced at a rate controlled by the setting of the sample rate potentiometer. (In many OEM instruments this front panel potentiometer has been replaced by a fixed resistor.)

c. M_1 fires upon receipt of a positive pulse at its input, driving the M_1+M_2 gate true. M_1 also sets L_1 which then sets L_o, turning off switch Q4 and Q23 and turning on switch Q3, applying E_X to A1. In system usage, M_1 provides a delay from the encode command to the beginning of the encoding, so that the input filters have time to settle.

d. When M_1+M_2 gate is driven true, it applies a reset pulse to all counters and to the overrange flip-flop, resetting them all to zero. M_1+M_2 also closes the clock gate to prevent any pulses from reaching the counter during M_1 time. M_1+M_2 gate also opens switch Q17 to prevent the integrating amplifier from integrating the input while the filter is slewing.

e. At the end of M_1 time the clock gate allows pulses to be fed to the counter and switch Q17 turns on, starting the integration of the output voltage from A1 which equals the gain of A1 times the attenuated E_X.

f. After 10,000 counts, the negative going edge of X_{83} will fire M3, causing L_1 to reset. L_1 resetting turns off Q3.

g. As L_1 resets, the positive going transition of $\overline{L_1}$ will fire M_2. M_2 resets L_R, turning on Q5. M2 again drives M_1+M_2 gate true, cutting off clock pulses to the counter and turning off Q17, stopping any further integration of A1's output. The zero detection circuits detect the polarity of the integrator's output and select $+E_R$ or $-E_R$ as required to make the integrator output slew toward zero. D4 and Q4 connect $+E_R$, and D3 and Q3 connect $-E_R$. M_1+M_2 gate going true also resets all counters to zero.

h. At the end of M_2, M_1+M_2 gate goes false, again allowing clock pulses to flow into the counter via gate Z10A and Z10B and turning Q17 on. Simultaneously, the negative going edge at the end of M_2 causes the polarity information from the zero Schmitt ($\overline{L_z}$) to be transferred into the polarity flip-flop, L_p, whose output controls the + and - symbols.

i. Integrator capacitor C12 starts to discharge toward zero volts and the counter starts counting up from zero, continuing until the integrator output crosses zero. At that time the zero-Schmitt changes state, resetting L_R. The positive going edge of $\overline{L}_R$ resets $\overline{L}_o$, turning on Q8 to prevent further pulses from getting to the counter. Also, the negative going edge of L_R fires M_4, causing a store pulse to be sent to the storage registers. This causes the new reading to be transferred from the counters to the storage registers and displayed. L_o also turns on Q4 and Q23 returning the meter to the condition described in 4-1-1; L_R at the same time turns off Q5.

4-3. CIRCUIT DESCRIPTION

All the voltmeter circuits in the DS-100 main frame and the plug-in modules are floating and guarded with respect to the AC power source. Power for the voltmeter is supplied through a triple-shielded transformer which is specially designed to minimize capacitance to power ground and current leakage from the AC power source. The guard surrounding the measuring circuitry is connected to the center of the three transformer shields and to the guard terminal on the front panel, and may be extended to the common mode source.

For discussion purposes, the voltmeter circuits have been divided into three sections; analog, digital, and power supplies. Analog ground is connected to the "LO" terminal on the front panel. Digital "ground" is on the -24V supply, for reasons which will become apparent later. For simplicity, digital ground will be referred to as -24V. Most of the digital circuits and power supplies are physically located on the top digital board.

MAINTENANCE NOTE

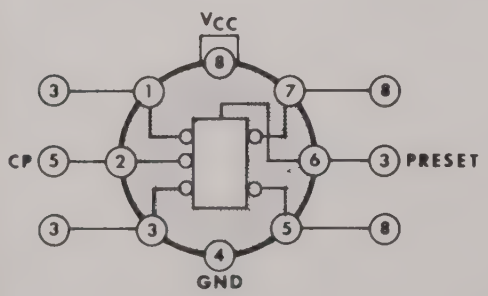
When measuring digital waveforms, the oscilloscope MUST be grounded to the -24V supply. However, the oscilloscope should be operated on an isolator plug or transformer in order to prevent any possible ground loop from shorting the -24V supply. Momentary shorting of the -24V supply will not cause damage, as the power supply has limiting protection.

4-4. DIGITAL CIRCUITS

Five types of digital integrated circuits are used in the DS-100; all are resistor-transistor logic (RTL), having positive (high) true logic levels.

a. The first logic type is the μL923 J-K flip-flop. Refer to Figure 4.4. Positive supply is on pin 8, and negative on pin 4. Outputs are on pins 7 and 5, only one of which should be true at a given time. The enable inputs for these outputs are pins 1 and 3, respectively. A low voltage on one of these pins will enable a negative going clock edge on pin 2 to set the related output to the low state. If both enable inputs are in the low (enabling) state, the flip-flop will toggle from one state to the other on successive clock pulses. Pin 7 output may be

LOGIC SYMBOL & LOAD FACTORS



TRUTH TABLE

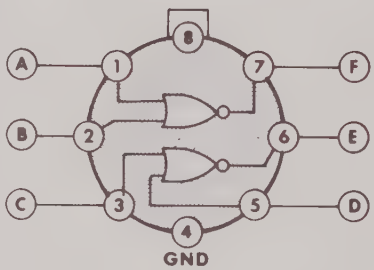
SET (1)	CLEAR (3)	OUTPUT (7)
	t=n	t=n+1
H	H	X^n
H	L	H
L	H	L
L	L	X^n

H is more positive than L.
X is the output state at time n.

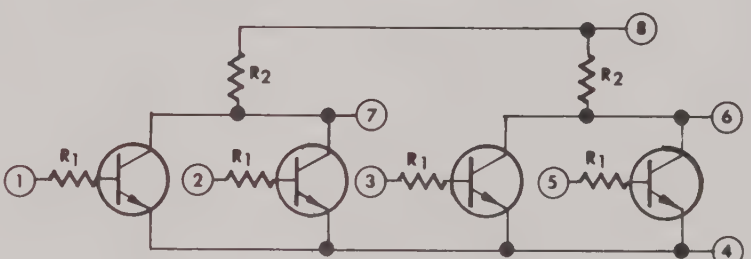
μL923 J-K FLIP FLOP fig 4.4

set to the low state by applying a high state to pin 6. This may be used as either a reset or preset depending on which output pin is defined as the true output.

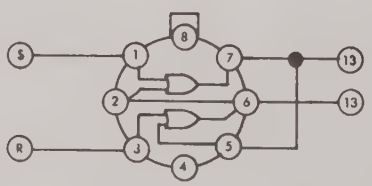
b. The μL914 contains two double input NAND/NOR gates. (Refer to Figure 4.4.) If pins 1 and 2 are low, the output will be high. If pins 1 or 2 is high, the output will be low. The same is true of the second gate. A frequent use of type μL914 is as an RS flip-flop (set/reset). See Figure 4.5. If one input to each gate is cross coupled to the output of the other gate, positive feedback will occur, causing flip-flop operation. If either free input is taken high, the corresponding output will go low. If both inouts are low, the last state will be stored. The normal logic levels for the μL914 and the μL923 are: 1.2V = high; 0.2V = low.



SCHEM DIAGRAM



R_1 = 450Ω
R_2 = 640Ω



INPUT		OUTPUT	
1	3	6	7
L	L	NC	NC
L	H	L	H
H	L	H	L
H	H	NOT ALLOWED	

NC = no change

μL 914 DUAL 2 INPUT GATE fig 4.5

c. Type CμL958 is a decade counter consisting of four cascaded binary triggered flip-flops modified by a feedback loop to count in the 8-4-2-1 code. See Figure 4.6. The false side of all flip-flops is brought out; a low state on an output indicates the bit is true. The count terminal (pin 9) provides an input for pulses while the reset terminal (pin 12) allows the counter to be reset to zero. Normal logic levels are 1.2V = high, 0.2V = low.

d. A Type CμL959 storage unit consists of four gated latch circuits, and a common gate driver. (See Figure 4.7.) Information which is present at the four data inputs enters the latches during the interval that the hold command is removed from the gate input terminal, pin 1. The hold command is a high

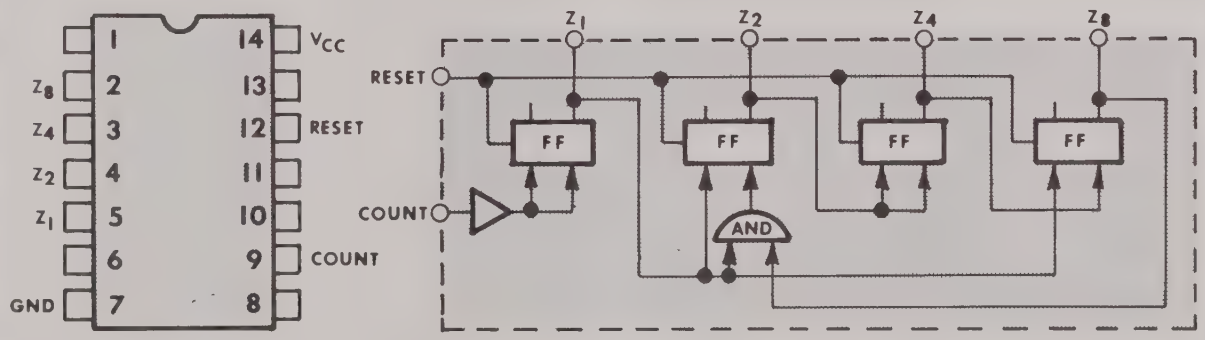
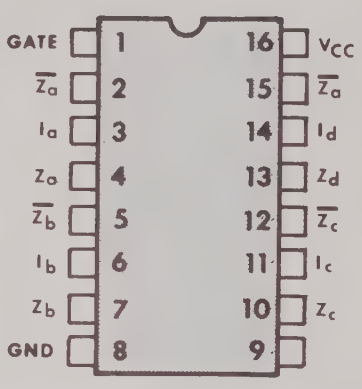


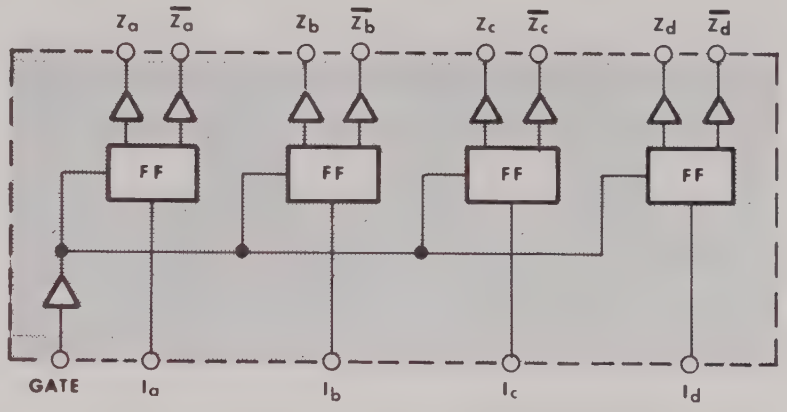
TABLE OF OUTPUT STATES

COUNT→	0	1	2	3	4	5	6	7	8	9
Z_1	H	L	H	L	H	L	H	L	H	H
Z_2	H	H	L	L	H	H	L	L	H	H
Z_4	H	H	H	H	L	L	L	L	H	H
Z_8	H	H	H	H	H	H	H	H	L	L

H = High
L = Low

CμL 958 DECADE COUNTER fig 4.6



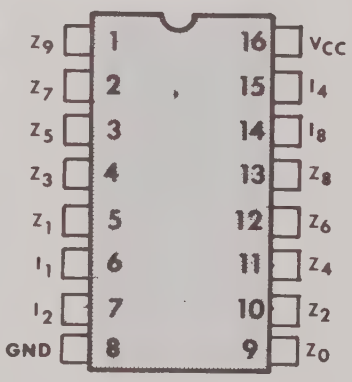


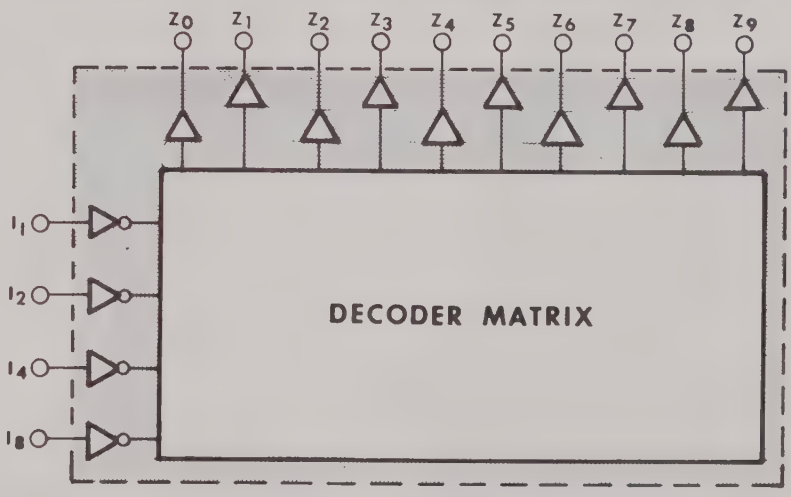
TRUTH TABLE

GATE	I	Z	$\overline{Z}$
L	L	L	H
L	H	H	L
H	ANY	Q	$\overline{Q}$

H = High
L = Low
Q = The state assumed prior to "GATE HIGH" is maintained.

CμL959 STORAGE REGISTER fig 4.7





TRUTH TABLE

I_1	H	L	H	L	H	L	H	L	H	L
I_2	H	H	L	L	H	H	L	L	H	H
I_4	H	H	H	H	L	L	L	L	H	H
I_8	H	H	H	H	H	H	H	H	L	L
on output	Z_0	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	Z_7	Z_8	Z_9

H = High
L = Low

CμL960 DECODER/DRIVER fig 4.7A

state. With gate input high, information is stored until pin 1 is taken low. Both the true and false sides of the latches are brought out; normal logic levels are 1.2V = high, 0.2V = low.

e. Type CμL960 decoder/driver is an integrated circuit which accepts negative (low) true 8-4-2-1 BCD inputs and produces high level ten-line outputs which can directly drive a Nixie tube (see Figure 4.7A). Normal input levels are identical to the μL959's; normal output levels are low = +4V max, high = +55V min.

4-4-1. SEQUENCING LOGIC CIRCUITS (Schematic #100-628)

a. SAMPLE RATE GENERATOR

The sample rate generator is a free-running multivibrator made up of a Schmitt trigger and an active integrator; Schmitt trigger is formed by inverters Q1 and Q2, with positive feedback supplied by R6. Input is applied on R4. Output of the Schmitt is fed through R9 and R10 to the integrator made up of C1 and Q3. Since the integrator always slews in such a direction as to cause the Schmitt to change state, the output of Q2 is a rectangular waveform which has a period roughly proportional to R9 + R10. As R9, the sample rate potentiometer approaches 100K, the oscillation stops due to lack of base drive for Q3; this is the HOLD position.

b. M1 MONO

Mono 1 is formed by an R-S flip-flop driving an active integrator, Q4 and an emitter follower Q5. Pin 7 of Z1A is normally true, causing the emitter of Q5 to be at -24V. A differentiated positive pulse from the sample rate generator on pin 2 sets the flip-flop and causes the integrator to slew positive, eventually resetting the flip-flop through pin 5. Circuit time constant is 55 milliseconds, and the output is fed to the clock through C4 as a sync signal. (In high speed meter with option E, the time constant is 5.5 ms.)

c. M2 MONO

Mono 2 is essentially the same as Mono 1 except that it is modified for a shorter time constant of 600 μs. The clock is fed to its output through C15 as a sync signal.

d. DUAL DIFFERENTIATOR

The dual differentiator is made up of the two gates in Z4. $\overline{L}_z$ from the zero crossing Schmitt is fed into pin 5 of Z4A to form L_z. L_z and $\overline{L}_z$ are then differentiated by C7, R19 and C6, R18. Resulting waveforms are fed to pins 1 and 2 of Z4B, and are amplified and inverted. Thus a positive pulse on either L_z or $\overline{L}_z$ becomes a negative pulse at pin 7, Z4B, and is sent to the toggle input (pin 2) of the reference flip-flop, L_R. Note that pin 7, Z4B is normally positive.

e. M4 MONO

Mono 4 creates a pulse to transfer the measurement from the counters to the buffer storage at the end of the encoding. This is accomplished by differentiating the negative going edge of L_R through C17 and R42 and amplifying it in Z11. Two gates are used as two inverters in series. Pin 7 is normally at -24V while pin 6 is normally positive. R41 and C18 provide a 2 μs delay in the store pulse so that any carry pulses traversing the counter at the end of the encoding can die out before the information is transferred to the data storage registers.

f. CLOCK

A two-inverter multivibrator forms the basis of the clock, with a parallel L-C circuit in the feedback of one inverter, Z5B, to control the frequency, along with C8. Two gates of Z5 are used as the inverters. The clock frequency is set at 100 KHz, thus generating a pulse to the clock gate at 10 microsecond intervals.

In the high speed Option E, a stable crystal resonant at 600 KHz replaces C8. This version of the instrument provides excellent normal mode noise rejection at 60 Hz and its multiples, as well as providing much faster overall measurement speeds.

g. CLOCK GATE AND BUFFER

The clock gate and buffer are made up of Q8, gate Z10A and gate Z10B. Two

resistors on the base of Q8 form a NOR gate. Between encodings, $\overline{L}_o$ is high, turning on Q8. When $\overline{L}_o$ goes to -24V, the clock signals drive Q8 through R31. Output of Q8 is fed to Z10A, which is gated by the M_1+M_2 gate signal; output of Z10A is fed back to the base of Q8 to provide AC positive feedback in order to square the signal. Z10B provides inversion to give the proper phase relationship.

h. OVERLOAD DETECTOR

The overload detector circuit logically ANDs $\overline{X_{14}}$ (10,000 counts) with $\overline{X_{23}}$ (2,000 counts) in gate Z12A to produce a positive output pulse after 12,000 counts. This positive pulse is applied at the set input to the R-S flip-flop, L_{OL}, to produce an overload indication. L_{OL} (Z13) drives Q14 to turn on the overload neon, providing a visual indication. Overload indication is stored until M_2 fires approximately halfway through the next encoding. M_2 resets L_{OL}. C31 prevents spurious set pulses from reaching L_{OL} while $\overline{X_{14}}$ and $\overline{X_{23}}$ are being reset.

i. POLARITY DETECTION

Information for polarity determination is available on the $\overline{L}_z$ line at the beginning of M_2. Gate Z4A of the dual differentiator inverts $\overline{L}_z$ and provides the enable inputs of the L_P flip-flop with both L_z and $\overline{L}_z$. The leading edge of $\overline{M}_2$ causes the new polarity information to be set into L_P. Polarity information is then displayed, with Q10 or Q11 turning on the appropriate neon.

j. OVERFLOW ONE

Principle of operation of the "overflow one" storage flip-flop, Z27 is the same as described above. X_{14} and $\overline{X_{14}}$ from flip-flop Z26 are applied to the enable inputs of Z27; leading edge of the store pulse causes the information to be transferred from Z26 to Z27 flip-flop. High voltage driver, Q19 displays the information through the "1" neon.

k. MISCELLANEOUS FLIP-FLOPS

L_1, L_o and L_{OL} are R-S flip-flops made up of μL914 gates as described in

section 4-4-b. L_R, L_P, X_{14} and Y_{14} are J-K flip-flops, as described in section 4-4-a.

4-4-2. DISPLAY COUNTER

The display counter is made up of four identical decades. Each decade is made up of an 8-4-2-1 BCD counter, a gated latch storage unit and a BCD to decimal decoder-driver. The counter accepts pulses from the clock gate and buffer output and divides the frequency by 10 (See Functional Block Diagram, 100-640). Output from the 8 bit is fed to the next decade. All four bits are fed to the storage unit. When the hold input goes false (-24V) at the end of the encoding, the four bits in the counter are transferred into the flip-flops in the storage unit. When the hold input is returned true (-22V), the storage unit ignores any changes in the state of the counter. Outputs of the storage unit are connected to the decoder-driver inputs. The decoder-driver contains internal logic which converts the binary information into one-out-of-ten information. Output is in the form of ten high-voltage driver lines which are connected to the ten cathodes of a Nixie tube.

4-5. POWER SUPPLIES (Schematic #100-628)

The power supplies include half or full bridge rectifiers with standard capacitor-input filter circuits. In addition, the integrated-circuit supply contains a high gain regulator circuit. All the voltage gain is in Q16 which has a constant current generator, Q15, as the collector supply. Q17 lowers the output impedance of the amplifier and drives the passing transistor, Q18. Q16 compares the output voltage, reduced by R66, R67, R68, with the reference voltage created by CR10, CR11. If the output voltage deviates from 4V, Q16 reacts to correct it. These supplies are located in the digital board assembly.

4-6. ANALOG CIRCUITS (Schematic #100-625)

Most of the analog circuits of the basic voltmeter are contained on two boards, the analog board and the reference board. Raw ±35V supplies for these boards are supplied by the digital board, and regulation is supplied by the analog board. The regulated 4V integrated circuit supply voltage, generated on the digital board, is also routed to the analog board.

4-6-1. ANALOG BOARD, SERIES "K"

4-6-1-1. ATTENUATORS

Those meters which have 100V and 750V ranges, will have a ten megohm input attenuator, composed of the 10 megohm R1, 100.909K R2, and calibration potentiometer R3. Relay K1 allows the attenuator to be by-passed on the lower ranges to provide higher input impedance. The calibration potentiometer sets the attenuator to perform a precise 100:1 division, the divider being inserted in front of the DVM on both the upper voltage ranges.

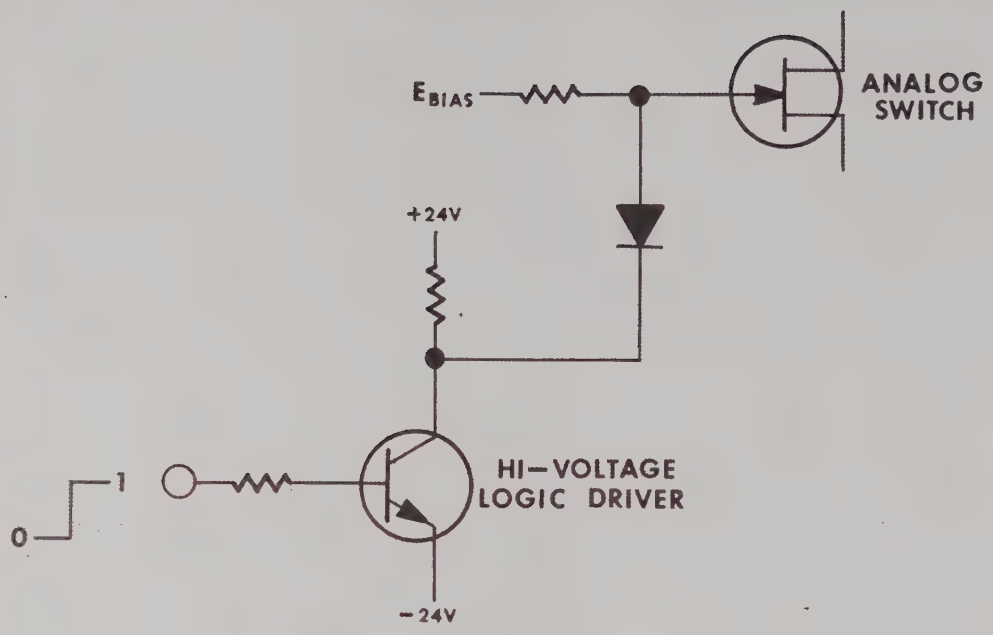
4-6-1-2. FILTER

The filter-limiter circuit is made up of a two-section low pass filter (R4, C1, R5, C2) with an overload protection limiter attached to the output of the first section. This prevents high voltage from damaging the buffer amplifier. FET's Q1 and Q2 connected as diodes, limit the voltage at this point to ±15V.

4-6-1-3. ANALOG SWITCHING

There are 8 analog switching channels in the instrument, which are all essentially identical (see Figure 4.8). Each channel is formed by a high-level driver and a junction field-effect transistor (FET) switch. Drivers convert I.C. logic levels to high voltage swings; the FET switches convert these high voltage swings to solid state "closures".

In Figure 4.8, when the driver output is positive, D1 is reverse biased, causing the gate to be zero-biased with respect to the source. As a result, a low impedance, (<1.0K) appears between drain and source. When the driver is negative, D1 pulls the gate negative, causing several thousand megohms to appear between drain and source. Either C1 or C2 may be incorporated in the driver, depending on what timing is required for proper operation. Note that S2 and S6 are both controlled by D2. Switch drivers include Q25 through Q30; the FET switches include Q3, Q4, Q5, Q17, Q18, and Q23 on the main analog board, and Q3 and Q4 on the reference board.



ANALOG SWITCHING CHANNEL fig 4.8

4-6-1-4. BUFFER AMPLIFIER

The buffer amplifier is a multiple-stage differential amplifier connected in the potentiometric feedback mode. The first differential stage is the dual field-effect transistor Q6A and Q6B. It is operated as a long-tailed pair with the constant current generator Q11 supplying the current to the sources. A second differential pair, Q7 and Q8, is driven by the output of the first pair. Collectors of Q7 and Q8 supply negative feedback to the sources of the first stage via R16 and R25. Resulting stabilized gain on these stages is approximately 300, and roll-off is provided by C4-R24 with CR4 and CR5 to give fast recovery from overloads. A third differential pair, Q13 and Q14 are driven by Q7 and Q8. Q14 in turn drives Q15 a common emitter stage. R28-C7 and R3 R31-C6 provide further roll-offs for shaping the frequency response. Q16 is an emitter follower which lowers the output impedance of Q15. Q10 and Q12 are cascaded emitter followers driven by the sources of the dual FET Q6A and Q6B. Output of Q12 drives zener diodes CR9 and CR8 to provide a floating supply for the first three amplifier

stages. Current for the zeners is supplied by constant current generator Q9. Since the anode of CR9 always tracks the sources of Q6A and Q6B, the cathode of CR8 must be a constant 12.4V positive of the sources, allowing Q6A, and Q6B, Q7, Q8, Q13, and Q14 to operate with a constant supply regardless of the voltage between the gates of Q6A/Q6B and analog ground.

Overall amplifier gain is selected by feeding back from one of four points on the output attenuator (R79, R80, R81, R82, and R83) to Q6 input. Selectable gains are 1.08, 10.8, 108 and 1080. The correction voltage, E_c, is summed into the feedback attenuator.

4-6-1-5. INTEGRATING AMPLIFIER

The integrating amplifier is a high input impedance, high gain operational amplifier. Its first stage is a field-effect source follower Q18 which has a very high input impedance and very low current offset (<40PA). The source-follower has a typical gain of 0.9. Its output drives the inverting input of an integrated-circuit operational amplifier Z1, which has a typical open loop gain of 20,000 and a typical output swing of ±12V. Capacitor C12 supplies negative feedback to the summing junction (gate of Q18) and R41 sets the full-scale current.

4-6-1-6. ZERO CROSSING AMPLIFIER

The zero crossing amplifier is a wide-band DC amplifier which detects the zero-crossings of the integrator amplifier. CR13, CR14, R47 and R48 form a current limiter to prevent overload of the integrating amplifier or damage to Q19. Q19 is a common-emitter stage which has an output buffer, Q20, to lower the output impedance. A DC level shifter formed by CR15 and CR16 drives the second common emitter stage, Q21. Local feedback stabilizes the gain at 10,000.

4-6-1-7. ZERO SCHMITT TRIGGER

The zero Schmitt trigger squares up the amplified zero-crossings to provide a logic level transition at the exact moment the integrator output crosses zero. It is formed by Z3A and Z3B. Positive feedback via R56 assures sharp transitions. While $\overline{L}_R$

is positive, G2 is held in the low state (negative), preventing the positive feedback action and allowing Z3A to act as a linear amplifier feeding Q22 in the auto-zero circuit. Z4A is an inverter to drive D4, for polarity selection.

4-6-1-8. AUTO-ZERO CIRCUIT

The auto-zero circuit is a single-stage voltage amplifier followed by a simple sample-and-hold circuit. Q22 is a common base stage with a gain of 50; it is rolled-off by R61 and C16. Q23 is a standard analog switch (described in 4-6-1-3), connecting the output of Q22 to the storage capacitor C17. Q24 is a high input impedance source follower which supplies the correction voltage E_c to the buffer amplifier. When an encoding starts, Q23 is turned off, and the last voltage required to zero the system is stored on C17. Thus, a continuous correction voltage is applied to the buffer amplifier.

4-6-1-9. OFFSET CIRCUIT

All Doric instruments with a sensitivity of greater than 10 μV/digit contain an offset circuit to buck out external thermal voltages. This circuit is made up of R9 through R14. By moving the wiper on R13 from the center to one end or the other, a change of ± 10 μV can be induced across R11. Since this voltage is in series with the input terminals, it can be used to buck out any thermal voltages in the input circuit.

4-6-1-10. 24V and 15V REGULATORS

The +24V and +15 regulators consist of a constant current supply, Q44, driving a 24V zener diode, CR41, followed by two emitter followers Q46 and Q47. Emitter followers are used to lower the output impedance. CR35, CR36, CR37 and R102 supply a constant voltage (with respect to +35V) for Q44. Since the diode drop of CR37 cancels the V_{BE} of Q44, two diode drops appear accoss R106, thus creating a constant current which flows through the collector of Q44 to CR41, causing it to zener at 24V. The output of CR41 feeds emitter follower Q46 which creates the +24V supply. The +15V supply is created by Q47 which derives its voltage from the divided-down +24V supply. The -24V and -15V supplies are identical to those described above except that the

polarities are reversed and NPN's replace PNP's and vice versa. The ±35 volt raw supplies for the above regulators are created on the digital board.

4-6-1-11. M_3 MONO

M_3 mono is an I.C. gate used as an inverter. R66 forces the input of the gate true, holding the output false. X_{83} going false causes a negative going edge on C18; this causes a differentiated spike to appear at the input of the gate. The gate will square up this spike to produce a rectangular 3 microsecond pulse, L_1 reset.

4-6-2. REFERENCE BOARD (Schematic #100-626)

The reference board contains a precision zener supply, reference polarity selection and the calibration networks. On the same board are the ratio amplifier and ratio calibration network when option "C" is included. The function of this board is to provide a highly stable voltage of a polarity and magnitude appropriate for comparison with the unknown voltage.

4-6-2-1. ZENER SUPPLY

The precision zener supply consists of a temperature-compensated constant current supply delivering an accurate current to an aged and temperature-compensated zener diode. A constant voltage -7.4V with respect to +24V, is developed across CR2, CR3, and CR4 and is applied to the base of Q1. The emitter of Q1 then develops a constant 6.8V across R1, R2, and R3, which are selected to deliver the exact current through CR1 for a zero temperature coefficient. Constant current flowing through CR1 will create a 6.2V output voltage which typically changes less than 5 parts per million/°C (2.2/ppm/°F).

4-6-2-2. CALIBRATION CIRCUITS

The 10V range calibration adjustment is a simple resistive divider with an output settable to precisely 5V, which is delivered into the constant 20K input impedance of the polarity selection network. This 10V calibration potentiometer (R7) is the "basic" calibration adjustment, which will change all ranges by the same percentage.

4-6-2-3. POLARITY SELECTION NETWORK

The polarity selection network changes the I.C. operational amplifier, Z1, from a potentiometric gain of 2 to an operational gain of -2. Polarity selection switches Q3, Q4, are the standard analog switches (see 4-6-1-3) which are used to switch the non-inverting input (pin 3) of the operational amplifier. When Q3 is on and Q4 is off, pin 3 is pulled to ground through R14, forcing the summing junction (pin 2) and one side of R13 to ground. Since the other side of R13 is connected to the +5V internal reference, 250 μa will flow into the summing junction. All of this current will flow out through R57, creating -250 μa x 40K = -10V potential at the output of the amplifier. Since R15 and R16 have no voltage across them, they have no effect when Q3 is on. When Q4 is on and Q3 is off, pin 3 of the amplifier is pulled to +5V, forcing pin 2 to +5V, putting 5V across R15 and R16, and 0V across R13. R57 must deliver +250 μa in order to develop the 5V across R15 and R16. +250 μa x (R15 + R16 + R57) = +10V. R16 allows the plus gain to be adjusted to match the minus gain. No current is drawn through R13, so that Q2 is turned on in this polarity, connecting R8 to ground, and maintaining the 20K input impedance.

4-6-2-4. REFERENCE DIVIDER

The reference divider is a simple, but precise, resistive divider which accepts the ±10V from the reference amplifier and derives from it ±1V, ±.1V and ±.01V. These voltages are adjustable by the range calibration potentiometers R29, R31, and R22, respectively.

4-6-2-5. RATIO OPTION (Schematic #100-626)

The ratio amplifier is an IC operational amplifier working in the potentiometric "gain of one" mode. Bias current for the non-inverting input is obtained from a temperature-compensating source, which supplies a current varying with temperature to track the bias requirements. Exit currents from the external reference input are thereby minimized. Output of the amplifier is divided down 2:1 by R43 through R46. When ratio function is selected, 5V is fed to the polarity selection circuits when 10V is applied on the input.

4-6-3. ANALOG BOARDS, SERIES "P", PROGRAMMABLE (Schematic #100-636)

The "P" plug-ins are remotely programmable, and change ranges by means of electronic switches and relays. Remote range information is transmitted from the I/O board in 8-4-2-1 BCD code. A BCD to decimal integrated circuit decoder Z2 converts this to a "1 out of 6" code. The output of the decoder drives electronic switches to select the appropriate buffer amplifier gain and reference voltage as shown below, and also drives the decimal points, "MV" neon and the attenuator relay. The "P" option also accepts the Auto-Range board to provide for automatic range changing.

BCD Range Code			Decimal Range Code						Voltage Range	MV	Gain	Ref. V.	Atten.
$R2^2$	$R2^1$	$R2^0$	R1	R2	R3	R4	R5	R6					
0	0	1	1						750.0V		x1	10V	100:1
0	1	0		1					100.00V		x10	1V	100:1
0	1	1			1				10.000V		x1	10V	1:1
1	0	0				1			1.0000V		x10	1V	1:1
1	0	1					1		100.00MV	1	x100	.1V	1:1
1	1	0						1	10.000MV	1	x1,000	.01V	1:1

4-7. SELF-CHECK SWITCH, OPTION B

The self check switch is a low-level push button switch which is in series with the "signal HI" input terminal. When actuated, the switch disconnects the meter from the "HI" terminal and connects it to the reference zener. If the meter is now placed in the 10V range, it will read its own zener voltage, (nominally 6.2 volts). This reading should agree with the last voltage recorded on the calibration log located on the reference shield. This procedure checks the basic range calibration except for the zener.

4-8. HIGH SPEED, OPTION E (Schematic #100-625 and 100-628)

The high-speed option E has a crystal controlled clock to provide a precise 16.666 MS integration time. This provides excellent normal mode rejection at 60 Hz and multiples of 60 Hz and allows overall 50 MS reading speed. Other changes with option E include shortened time constants on the sample rate generator (0 to 20 Hz), M1 (5 MS),

integrator time constant (22 MS), auto-zero time constant (1.5 MS), filter time constant (≈.5 MS). In other respects, option E is identical to the slower meter.

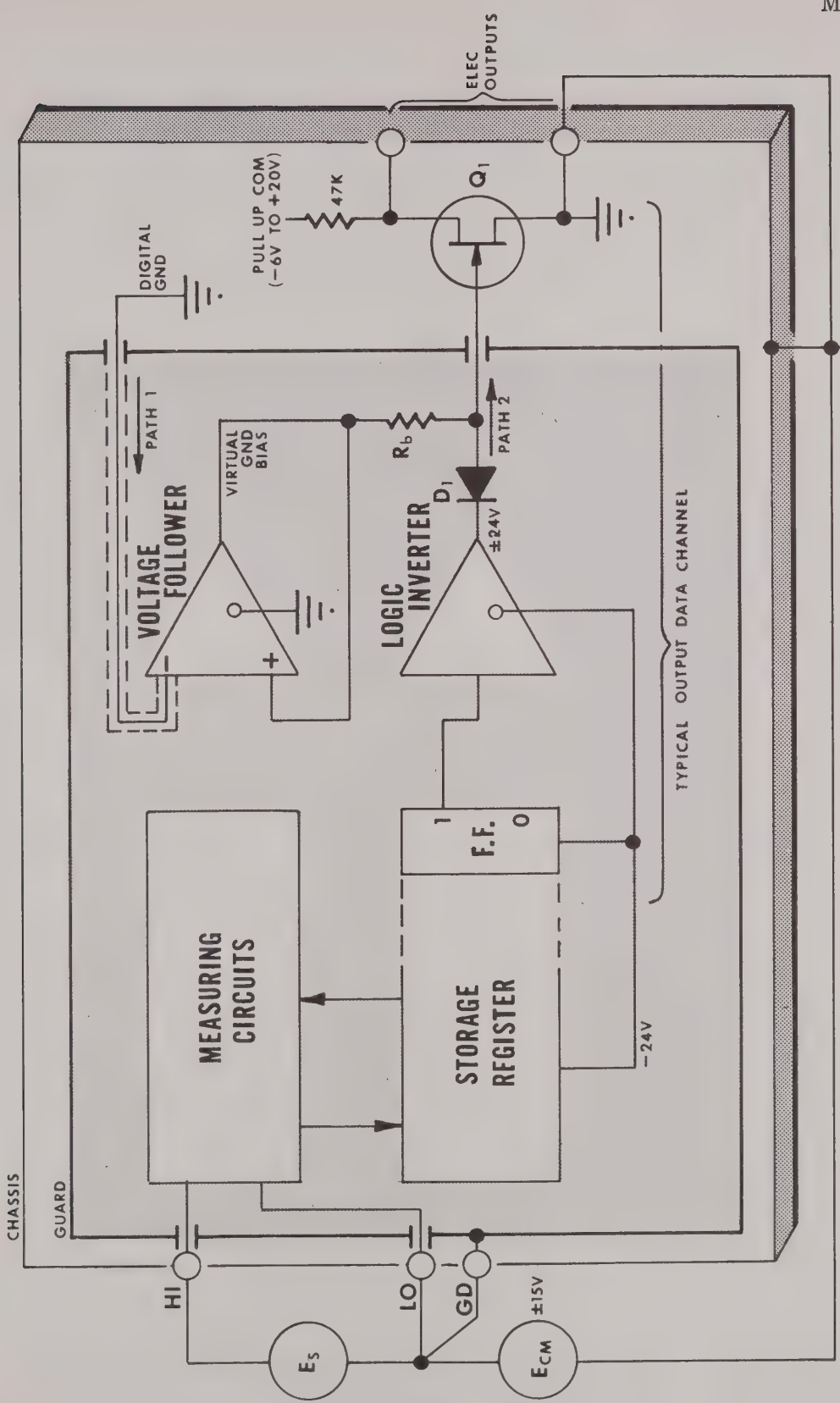
4-9. I/O BOARDS S3-1, S4-1, S4-2 (Schematic #100-636)

Figure 4-9 shows a block diagram of the differential solid state guard-crossing technique. A typical output data channel is illustrated. The flip-flop drives an analog switching channel as discussed in 4-6-1-3. When the inverter output is at -24V, Q1 is off, and the gate is reverse biased. This presents a very high (>1000M) impedance to common mode path 2.

When the logic inverter is at +24V, D1 is reverse biased and Q1 is on. The gate of Q1 is zero biased and virtually no current flows through path 2 for any E_{cm} from +15V to -15V.

The only other common mode path is path 1, but as this is field effect input of a precision voltage follower, the input impedance is far in excess of 1000 megohms. The voltage follower provides a common biasing point for output bias resistor R_b, which drives Q1's input capacity, nullifying its effect.

The input data channels use a similar technique. The gate of the FET is driven by the incoming logic signals. The source and drain of the FET are referenced to voltages supplied by the virtual ground amplifier. A logic driver connects to the source and translates the digital signals to appropriate internal logic levels.



SOLID-STATE GUARD CROSSING BLOCK DIAGRAM fig 4.9

SECTION V

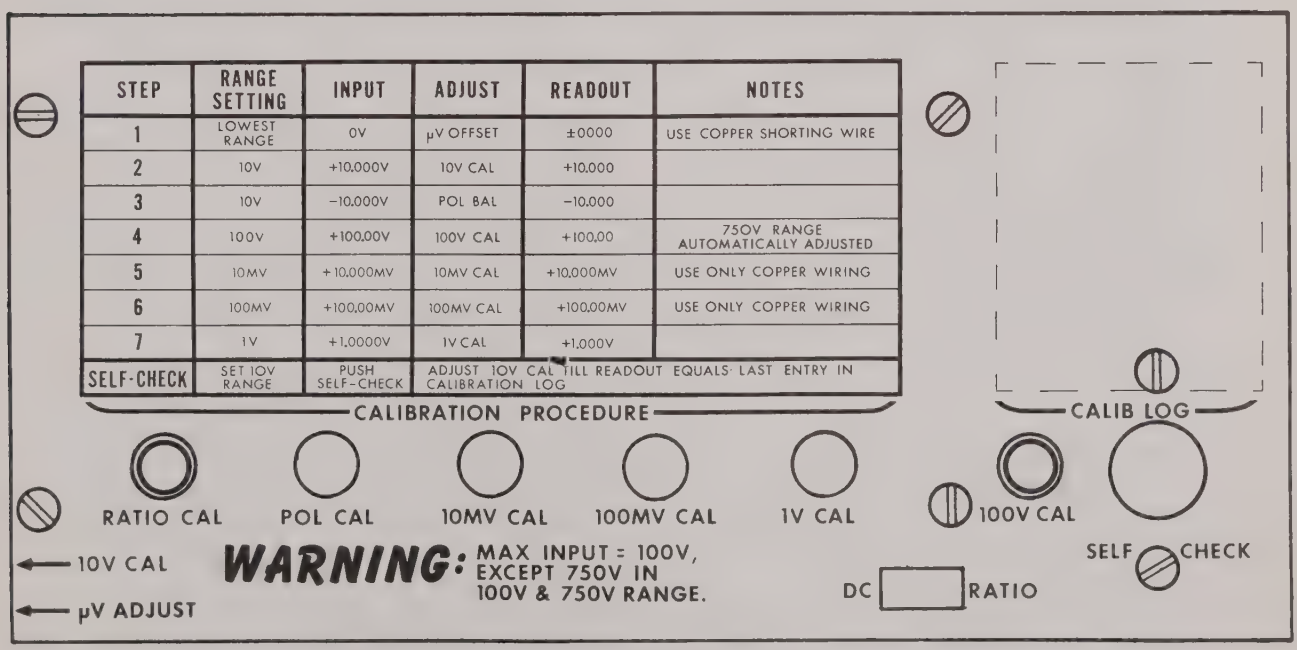
CALIBRATION

5-1. GENERAL

Basic calibration procedures are silk-screened on the internal calibration panel of each plug-in module as illustrated by Figure 5.1. This section provides a list of test equipment required for calibration and detailed instructions to supplement the basic procedures.

5-2. CALIBRATION PROCEDURES

The calibration procedure panel contains instructions for seven steps; given for each step is the range to which the meter is set, the input voltage, the name of the adjustment to be made, and the readout which must be obtained. For example, step 1 consists of (a) setting the range to 10MV, (b) shorting the input, (c) adjusting the μV OFFSET setting until (d) a readout of ±0.000 is obtained. The meter must be run for one hour



INTERNAL CALIBRATION PANEL fig 5.1

with the plug-in closed, to obtain a stable internal temperature. After warm-up, the plug-in latch is released, causing the unit to slide out about 1-1/2 inches to give access to the calibration controls.

NOTE

This will allow cooler air to circulate within the instrument, which will tend to upset the thermal balance. For this reason, calibration of the 10MV range only should be completed as quickly as possible. If calibration on that range cannot be completed within one minute, the plug-in should be closed and the instrument allowed to warm up again before proceeding.

5-3. EQUIPMENT REQUIRED - ALL K SERIES & P SERIES PLUG-INS

A DC voltage calibrator is required with sufficient dynamic range to cover the DVM ranges; a typical example for 100MV to 1000V ranges would be Fluke 332B, Cohu 303B or 304.

10MV Range. Most commercially available calibrators are not sufficiently quiet or thermally stable for calibration to .01% on the 10MV range. Generally, the only suitable equipment is a low-thermal microvolt laboratory-type potentiometer, such as Honeywell 2768 or 2773.

5-4. CALIBRATION OF SINGLE-RANGE PLUG-INS

a. Follow warm-up procedure as in 5-2.

b. If unit is 10MV FS, short the input before opening plug-in. Open plug-in and adjust the μV OFFSET control for proper zero as shown in calibration procedure step 1 (see Figure 5.1), making the adjustment as quickly as possible.

c. If unit has a range greater than 10MV FS, proceed to step d.

d. Remove short from input and connect a DC calibrator with sufficient voltage output for full scale of the range to be calibrated. Set calibrator for the exact positive full scale (+9999 or +10000) of the meter.

e. Adjust the 10V CAL control until the readout displays a positive full-scale reading identical to the positive voltage input.

f. Change the polarity of the input voltage from the calibrator to negative, but keep the voltage exactly the same as in step d., i.e., meter full scale.

g. Adjust the POL-BAL (polarity balance) control until the readout displays a negative full-scale reading identical to the negative voltage input.

5-5. CALIBRATION OF MULTI-RANGE PLUG-INS

a. Follow warm-up procedure as in 5-2.

b. If plug-in has a 10MV FS range, short the input before opening plug-in. Open plug-in and adjust the μV OFFSET control for proper zero as shown in calibration procedure step 1 (see Figure 5.1), making the adjustment as quickly as possible.

c. If plug-in has no 10MV FS range, proceed to step d.

d. Remove the short from the input, set plug-in to its 10V FS range, and connect a DC calibrator set to +10.000 volts DC.

e. Adjust 10V CAL control until the readout displays exactly +10.000 volts.

f. Change the polarity of the input voltage from the calibrator to negative, but keep the voltage exactly the same as in step d, i.e., -10.000 volts.

g. Adjust POL-BAL (polarity balance) control until the readout displays a negative reading identical to the negative voltage input, i.e., -10.000 volts.

h. Change range of plug-in to 10MV FS and set calibrator to +10.000MV. If no 10MV FS range, proceed to the section covering the lowest range of the instrument.

i. Adjust 10MV CAL control until readout displays +10.000MV.

j. Change range of plug-in to 100MV FS and set calibrator to +100.00MV.

k. Adjust 100MV CAL control until readout displays +100.00MV.

l. Change range of plug-in to 1V FS range and set calibrator to +1.0000 volts.

m. Adjust 1V CAL control until readout displays +1.0000 volts.

n. Change range of plug-in to 100V FS and set calibrator to +100.00 volts.

o. Adjust 100V CAL control until readout displays +100.00 volts. The 750V range will automatically be correctly calibrated if the 1V FS and 10V FS ranges are properly adjusted.

p. Push plug-in fully into place in instrument and secure latch. Allow 30 minutes additional warmup.

q. Recheck zeros and full scale calibration on all ranges.

r. If any readjustment on 10MV FS range is needed, pull out plug-in and readjust as quickly as possible, closing plug-in as soon as completed. Recheck and adjust until all zeros and full scale readings are correct.

s. On meters having self-check option, after completing calibration, set to 10V FS range, push SELF-CHECK button and note exact reading. Record reading and date on calibration log (see Figure 5.1).

NOTE

To use self-check, set meter to 10V FS range, press SELF-CHECK CHECK button. Reading should be within ±1 digit of the last recorded reading in the calibration log if calibrated correctly.

5-6. CALIBRATION OF RATIO RANGES

a. Follow same warmup procedures as in 5-2.

b. Apply a +10VDC signal to both the "Reference Input" and the "Signal HI" lines, with negative connected to "Signal LO", with meter switched to the 10V FS (1:1) range.

c. Switch meter to ratio mode by means of ratio switch located on the plug-in sub-panel.

d. Adjust the RATIO CAL control on sub-panel for a readout of 10.000. If all the DC voltage ranges have been correctly adjusted, they will now read out correct ratio values without further adjustment.

SECTION VI

TROUBLESHOOTING

6-1. INTRODUCTION

It is unlikely that your Doric instrument will need any repairs during its lifetime. In case the situation does arise, a novel program of trouble analysis has been worked out which is both effective and easy to follow. After the program will be found pin charts, voltage charts and hold condition checkout chart.

6-2. NOTES ON CIRCUIT ANALYSIS

Once a fault has been isolated to a given circuit, the following steps should be taken before replacing components:

1. Check the theory of operation, Section IV, and circuit description section given in fault isolation program. This will tell what the circuit is supposed to do and how it should operate.
2. Analyze the input waveform for proper voltage levels and rise or fall times.
3. Check for abnormal loads on circuit in question. The schematic will help in finding what the normal load is.
4. Trace signal path in the circuit, component by component with an ohmmeter to ensure that there are no abnormal opens or shorts.
5. Replace bad components as required.

6-3. TROUBLESHOOTING PROGRAMS

The following pages contain the programs, which, when worked through systematically, will locate a malfunction in any part of the instrument. Each initial item in each sequence contains a question, the answer to which is a simple yes or no. Each answer leads to the next step or path in the program, logically eliminating each possibility until the trouble is located.

FAULT ISOLATION PROGRAMS

Step No.	Procedure	If YES, Go to Number	If NO, Go to Number
1	Are all power supplies OK per paragraph 6-5?	7	2
2	Are all loads normal per paragraph 6-5?	3	6
3	Are fuses OK?	5	4
4	Replace fuses, return to 1.	-	-
5	Analyze bad power supply; correct fault and return to 1.	-	-
6	Analyze incorrect load; correct fault; return to 1.	-	-
7	Set front panel control to HOLD, check if circuit conditions agree with paragraph 6-6.	8	Go to step shown in chart 6-6.
8	Is sample rate generator oscillating?	9	28
9	Is M_1 firing?	10	31
10	Does M_1 set L_1?	11	31
11	Does L_1 set L_o?	12	31
12	Does $M_1 + M_2$ gate go true?	13	31
13	Does M_1 end correctly?	14	31
14	Does clock gate allow pulses to flow to counter?	15	31
15	Does 8-bit 10^3 decade divide input frequency by 10,000?	16	99
16	Does 8-bit (X_{83}) fire M_3 on going negative?	17	99
17	Does M_3 reset L_1?	18	99
18	Does $\overline{L}_1$ positive-going transition fire M_2?	19	99
19	Does M_2 set L_R?	20	99
20	Does L_R turn on Q5 via D7?	21	31
21	Does Q5 cause A1 output to be same polarity as A2 output?	22	46
22	When A2 output slews towards -.5V, does it cause L_z and $\overline{L_z}$ to change state?	23	46

Step No.	Procedure	If YES, Go to Number	If NO, Go to Number
23	When L_z and $\overline{L_z}$ change state, does it reset L_R via dual differentiator?	24	88
24	When $\overline{L_R}$ goes positive does transition reset L_o?	25	31
25	Does $\overline{L_o}$ cut off clock pulses?	26	31
26	Does negative L_R transition fire M_4?	27	31
27	Does M_4 pulse transfer counter information into storage registers?	34	31
28	Is control potentiometer tuned fully CCW?	30	29
29	Turn control potentiometer fully CCW and return to 8.	-	-
30	Analyze sample rate generator, correct fault; return to 8.	-	-
31	Are waveforms from previous circuit OK?	32	33
32	Check operation of circuit in question using circuit description, correct fault and return to the step taken prior to 31.	-	-
33	Check operation of previous circuit, using circuit description, correct fault and proceed along YES route.	-	-
34	End of encoding sequence.	-	-
35	Refer to Section IV, Paragraph 4-4-1. Analyze Q1, Q2, Q3 and associated circuitry. Correct fault and return to step 8.	-	-
36	Refer to Section IV, Paragraph 4-4-1. Analyze M_1 circuitry, correct fault and return to step 8.	-	-
37	Refer to Section IV, Paragraph 4-4-1. Analyze M_1 and M_2 gate; correct fault and return to step 8.	-	-
38	Refer to Section IV, Paragraph 4-4-1. Analyze M_2; correct fault and return to step 8.	-	-
39	Refer to Section IV, Paragraph 4-4-1; analyze M_3, correct fault and return to step 8.	-	-
40	Refer to Section IV, Paragraph 4-4-1; analyze M_4, correct fault and return to step 8.	-	-
41 thru 45	Unassigned		

Step No.	Procedure	If YES, Go to Number	If NO, Go to Number
46	Is A2 output more positive than -.5V?	58	47
47	Is zero amplifier output approximately -20V?	48	66
48	Is pin 7 of Z3 true?	49	67
49	Is L_R true?	50	19
50	Is L_Z in opposite state to pin 7 of Z3?	51	60
51	Is $\overline{L_Z}$ in opposite state to L_Z?	52	61
52	Is D3 in opposite state to L_Z?	53	62
53	Is D4 in opposite state to $\overline{L_Z}$?	54	62
54	Is D4 at +24V?	55	63
55	Is R14 on reference board at +5V?	56	69
56	Is the output of ±10 volt reference at +10V?	57	70
57	Is output of A1 equal to reference voltage multiplied by the gain of A1? (For gain of A1, see range chart in Section I, Paragraph 1-3-2.)	80	65
58	Is output of zero amplifier approximately 0V?	59	66
59	Is pin 7 of Z3 false?	49	67
60	Check Z3, correct fault, and return to No. 50.	-	-
61	Check Z4, correct fault, and return to No. 51.	-	-
62	Replace faulty transistor and return to previous step.	-	-
63	Is R14 on reference board at 0 volts?	64	68
64	Is the output of ±10 volt reference at -10V?	57	70
65	Is D7 at +24V?	84	71
66	Analyze zero amplifier, correct fault, return to No. 47 or No. 58.	-	-
67	Analyze Z3, correct fault, return to No. 48 or No. 59.	-	-
68	Analyze Q3 circu t, correct fault and return to No. 63.	-	-
69	Analyze Q4 circuit, correct fault and return to No. 55.	-	-
70	Analyze Reference Amplifier, correct fault and return to No. 56 or No. 64.	-	-
71	Analyze D7 inverter, correct fault and return to No. 65.	-	-

Step No.	Procedure	If YES, Go to Number	If NO, Go to Number
72 thru 79	Unassigned		
80	Is A1 output applied to R42 (A2 input)?	81	93
81	Is A2 output slewing opposite direction to A2 input?	82	86
82	Does A2 output cross -.5V?	46	87
83	Deleted		
84	Is A1 input at same voltage as reference output? For reference voltage outputs, see No. 91.	85	92
85	A1 not operating correctly; short input to ground and go to No. 133.	-	-
86	Analyze A2, correct fault and return to No. 81.	-	-
87	If A2 output crosses -.5V but oscillates about that value, go to No. 88.	-	-
88	Is the $\overline{L_Z}$ oscillation reaching pin 5 of Z4, on the digital board?	89	95
89	Is pin 7 Z4 on digital board putting out differentiated pulses?	90	96
90	Does $\overline{L_R}$ go true?	24	97
91	Check reference voltages per range chart, Section I, Paragraph 1-3-2.	-	-
92	Q5 not "on". Analyze circuit, correct fault and return to No. 84.	-	-
93	Is D5 at +24V?	94	98
94	Q17 not "on". Analyze circuit, correct fault and return to No. 93.	-	-
95	Trace oscillation through connector wiring, circuit straps, etc., correct fault, return to No. 88.	-	-
96	Analyze dual differentiator, correct fault and return to No. 89.	-	-
97	Analyze J-K flip-flop, correct fault, return to No. 90.	-	-
98	Check M_1 and M_2, correct fault and return to No. 93.	-	-

Step No.	Procedure	If YES, Go to Number	If NO, Go to Number
99	Does 8-bit in 10^0 decade divide input by 10?	100	103
100	Does 8-bit in 10^1 decade divide input by 100?	101	104
101	Does 8-bit in 10^2 decade divide input by 1000?	102	105
102	Does 8-bit in 10^3 decade divide input by 10,000?	Dividers are OK	106
103	Analyze 10^0 decade counter, correct fault, return to No. 99.	-	-
104	Analyze 10^1 decade counter, correct fault, return to No. 100.	-	-
105	Analyze 10^2 decade counter, correct fault, return to No. 101.	-	-
106	Analyze 10^3 decade counter, correct fault, return to No. 102.	-	-
107 and 108	Deleted		
109	Is A1 output +3V or greater?	122	110
110	Is A1 output -3V or less?	111	122
111	Is base of Q16 -2.5V or less?	112	117
112	Is there a voltage drop across R28 of less than 2V?	113	118
113	Is base of Q14 greater than .1 volt negative with respect to base of Q13?	114	119
114	Is base of Q7 greater than .1 volt negative with respect to base of Q8?	115	120
115	Is gate of Q6B greater than .01 volt negative with respect to gate of Q6A?	116	121
116	Analyze A1 output divider string, correct fault, and return to No. 115 or No. 126.	-	-
117	Analyze circuits associated with Q16, checking for overloads, correct faults and return to No. 111 or No. 122.	-	-

Step No.	Procedure	If YES, Go. to Number	If NO, Go to Number
118	Analyze circuits associated with Q16, checking for overloads, correct faults and return to No. 112 or No. 123.	-	-
119	Analyze Q13 and Q14 circuits, correct faults and return to No. 113 or No. 124.	-	-
120	Analyze Q7 and Q8 circuits, correct faults and return to No. 114 or No. 125.	-	-
121	Analyze Q6 and Q7 circuits, correct faults and return to No. 115 or No. 126.	-	-
122	Is base of Q16 greater than +3.5V?	123	117
123	Is there a voltage drop across R28 of greater than 6V?	124	118
124	Is base of Q14 greater than .1V positive with respect to base of Q13?	125	119
125	Is base of Q7 greater than .1V positive with respect to base of Q8?	126	120
126	Is gate of Q6B greater than .01V positive with respect to gate of Q6A?	116	121
127	Is E_{cm} at 0 volts ±.2V?	109	128
128	Is junction of R12 and R13 at less than +4V and greater than 0V with respect to ground?	129	134
129	Is emitter of Q10 .5V negative with respect to R12 and R13?	130	135
130	Are Q12, CR8, CR9 operating satisfactorily?	131	136
131	Is E_{cm} more negative than -.2V?	132	137
132	Analyze constant current generator Q9, correct faults and return to No. 131.	-	-
133	Refer to Section IV for theory of operation and go to No. 127.	-	-
134	Analyze R12, R13, Q6, correct faults and return to No. 128.	-	-
135	Analyze Q10 and associated resistors, correct faults and return to No. 129	-	-

Step No.	Procedure	If YES, Go to Number	If NO, Go to Number
136	Analyze Q12, CR8, CR9, correct faults and return to No. 130.	-	-
137	Is E_{cm} more positive than +0.05V?	138	127
138	Analyze constant current generator Q11, correct fault and return to No. 131.	-	-

6-4. PIN CHART

The following chart shows the various logic elements as designated in the theory of operation and in the schematics, together with the board on which each element is located. The third column shows the pin upon which the "true/false" output appears, while the fourth column shows the pin on which the NOT output (when this is utilized) is found.

Logic Designator	Board	True/False Output Location	Location of NOT Side
M_1	DIG	Z1 PIN 6	Z1 PIN 7
M_2	DIG	Z7 PIN 6	Z7 PIN 7
M_3	ANA	Z5 PIN 6	
M_4	DIG	Z11 PIN 7	Z11 PIN 6
L_o	DIG	Z3 PIN 7	Z3 PIN 6
L_i	DIG	Z2 PIN 7	Z2 PIN 6
L_P	DIG	Z8 PIN 7	Z8 PIN 6
L_R	DIG	Z9 PIN 5	Z9 PIN 7
L_z	ANA	Z3 PIN 6	Z4 PIN 6
$R2^0$	ANA	J1 PIN H	
$R2^1$	ANA	J1 PIN E	
$R2^2$	ANA	J1 PIN F	

6-5. NORMAL POWER SUPPLY VOLTAGES AND LOAD RESISTANCES

Nominal Voltage	Actual Voltage	Load Resistance (Analog Bd.)	Load Resistance (Digital Bd.)
+32V	+34 ±5V	>10K ohms	>50K ohms
-32V	-34 ±5V	>10K ohms	>50K ohms
+24V	+24 ±1.5V	> 5K ohms	---
-24V	-24 ±1.5V	> 5K ohms	>15K ohms
+15V	+15 ±1.0V	>20K ohms	---
-15V	-15 ±1.0V	>20K ohms	---
+4V (-20 to -24)	+4 ±.4V	>150 ohms	>12 ohms
+190V	+170V ±20V		>50K ohms
+6.2V reference	+6.2V ±5%		---

NOTE: Load resistances should be measured with the power off and the analog board pulled out of the meter. All load resistances should be measured with respect to ground except +4V which is measured with respect to -24V. The ohmmeter terminal must have the same polarity as the power supply being measured. These measurements are to be made with an ohmmeter having a 1.5V voltage source.

6-6. HOLD CONDITION CHECKOUT CHART

NOTE: The hold condition is set by turning sample rate control fully clockwise.

Logic Level	Logic State or Voltage	Step No.
S.R.G. (Q1)	0	35
M_1	0	36
L_1	0	8
L_o	0	8
$M_1 + M_2$	0	37
M_2	0	38
L_R	0	8
D1 (Q25)	-24V	8
D2 (Q26)	+24V	8
D3 (Q27)	+24V	8
D4 (Q28)	-24V	8
D5 (Q29)	+24V	8
D7 (Q30)	-24V	8
M_3	0	39
M_4	0	40

Analog Test Pin	Voltage	Step No.
10V Ref.	-10V	52
Buffer Output (E_B)	0V ±1V	133
Integrator Out (E_I)	-.5V ±.1V	46
Zero Amp Out (E_Z)	-13V ±5V	46
Auto-Zero (E_c)	0V ±20V	*

*See Section IV, Paragraph 4-1-1, analyze auto-zero.

SECTION VII

PARTS LISTS AND SCHEMATICS

7-1. INTRODUCTION

The parts lists in this manual are set up in individual sections for the sake of clarity. Paragraph 7-2 contains the parts used in the basic DS-100 meter, including all parts which are common to all of the models in the K and P Series. It is subdivided into the chassis assembly, analog board assembly, reference board assembly, and digital board group assembly. Paragraph 7-3 includes the parts, other than common parts, which are used in each individual model in the K and P Series. Paragraph 7-4 includes the parts, other than common parts, which are used in each individual option (B, C, S3-1, W, X, etc.). Paragraph 7-5 includes the schematics and logic diagrams for the Doric DS-100 Series.

7-2. BASIC DS-100 PARTS LIST

(PARTS COMMON TO ALL K AND P MODELS)

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
Schematic 100-628-04, 100-625-05	DS-100 Basic Chassis Assembly						
	Side Rail, Right	Doric	100-205-04	100-205-04	1		
	Side Rail, Left	Doric	100-206-05	100-206-05	1		
	Bail Set, Complete with feet	Buckeye Stamping	7" w/feet	991-055-01	1		
	Front Bezel	Doric	100-203-02	100-203-02	1		
	Cover, Top	Doric	100-207-00	100-207-00	1		
	Shield, Reference	Doric	100-223-05	100-223-05	1		
	Binding Post, White	Pomona	2382-9	973-300-03	1	1	2.31
	Binding Post, Red	Pomona	2382-2	973-300-02	1	1	2.31
	Binding Post, Black	Pomona	2382-0	973-300-01	1	1	2.31
	Shield, Bottom	Doric	100-214-03	100-214-03	1		
	Lock, Nylon	Doric	100-249-01	100-249-01	1		
	Spring, Lock	Doric	100-219-04	100-219-04	1		
	Cover, Bottom	Doric	100-208-00	100-208-00	1		
	Lever, Bottom	Doric	100-218-02	100-218-02	1		
	Slider Bracket	Doric	100-212-02	100-212-02	1		
	Slider Strip	Doric	100-213-00	100-213-00	2		
	Spring, Plunger	Doric	100-243-00	100-243-00	2		
	Spacer, Plunger 1/4 x 2-1/2	H. H. Smith	8352	991-020-22	2		
J1, 2	Connector, Interconnecting	Cinch	251-22-30-341	973-010-08	2		
J4	Connector, 2 pin	Winchester	JF2P2S	973-020-01	1		
T1	Power Transformer	Aztec	10344	100-701-05	1		
	Connector Mounting Bracket	Doric	100-211-05	100-211-05	1		
	Bezel, Rear	Doric	100-204-05	100-204-05	1		
	Handle, Carrying	National Lock	C244-26D	991-050-01	1		
	Clamp, Heyco	H. H. Smith	939	991-056-20	1		
J3	Power Cord	Belden	17237B	993-200-01	1		
F1	Fuse, Power 1/4A, Slo-Blo	Littlefuse	313.250	971-010-01	1	2	.42

BASIC CHASSIS ASSEMBLY (Sheet 2 of 2)

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
	Fuse, Holder	Littlefuse	342004A	971-080-01	1		
	Filler Panel	Doric	100-215-00	100-215-00	1		
	Input Plug, Single	Pomona	2944	973-200-01	1		
	Input Plug, Dual	Pomona	2244	973-200-02	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
Schematic 100-625 05	Analog Board Assembly						
	Circuit Board, Analog	Doric	100-225-04	100-225-04	1		
Z1	Integrated Circuit	Motorola	SC4715G	100-726-00	1	1	7.00
Z3,4,5	Integrated Circuit, CμL	Fairchild	91428-751	965-500-00	3	1	2.16
Q17,18,23, 24	Transistor, FET - High Leakage	Amelco	U1742	100-722-00	4	1	2.40
Q1-5	Transistor, FET-Low Leakage	Amelco	U1742	100-732-00	5	1	3.60
Q6A,6B	Transistor, Dual	Amelco	SU2211	100-724-00	1	1	13.50
Q7,8,12, 15,19,21, 48	Transistor, 2N4250	National SC	2N4250	962-425-00	7	1	1.60
Q9,44	Transistor, 2N3638	Fairchild	F2N3638732	962-363-80	2	1	1.12
Q16	Transistor, 2N3567	Fairchild	F2N3567814	962-356-70	1	1	1.24
Q11,22, 25-30	Transistor, 2N3877A	G. E.	2N3877A	962-387-11	8	1	1.20
Q10,13,14 20,45,47	Transistor, 2N3393	G. E.	2N3393	962-339-30	6	1	.72
Q49	Transistor, 40406	RCA	40406	964-040-02	1	1	3.48
Q46	Transistor, 40347	RCA	40347	964-040-00	1	1	1.92
CR1-5,10, 11,13-17 35-40	Diode, 1N914	Continental Devices	1N914	961-091-40	18	4	.50
CR6-9	Diode, Zener, 6.2V	Transitron	1N753A	961-075-31	4	1	1.20
CR41,42	Diode, Zener, 24V	Continental Devices	1N970B	961-097-02	2	1	1.20
C10	Capacitor, 22PF,10%,Disc	RMC	22NPO	901-012-20	1		
C2	Capacitor, .068μFD,10%, Polystyrene	Elpac	PD5A683K	913-036-83	1		
C4	Capacitor, .068μFD, 10%, Polycarb	Elpac	B1A683J	911-036-83	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
C6	Capacitor, .0047μF, 10%, Mylar	G. E.	75F1R4A472	912-064-72	1		
C7, 8, 19, 21, 22, 24-26	Capacitor, 100PF, 10%, Disc	RMC	JL100X5F	901-011-01	8		
C5, 20, 23	Capacitor, .001μFD, 20%, Disc	RMC	BA.001Y5U	900-081-03	3		
C3, 9, 11, 13 14, 16, 18, 27-30	Capacitor, .01μFD, 20%, Disc	RMC	TA.01Y5U	900-021-04	11		
C12, 1	Capacitor, .22μFD, 10%, Polystyrene	Elpac	PD5A224K	913-042-24	2		
C17	Capacitor, .22μFD, 10%, Polycarb	Elpac	B1A224J	911-032-24	1		
R83	Resistor, Metal Film, 1%, 56.2Ω	Corning	RN60D Series	920-356-29	1		
R123, 124	Resistor, Metal Film, 1%, 215Ω	Corning	RN60D Series	920-321-50	2		
R82	Resistor, Metal Film, 1%, 511Ω	Corning	RN60D Series	920-351-10	1		
R79, 81	Resistor, Metal Film, 1%, 5.11K	Corning	RN60D Series	920-351-11	2		
R126, 127	Resistor, Metal Film, 1%, 8.25K	Corning	RN60D Series	920-382-51	2		
R4	Resistor, Metal Film, 1%, 24.9K	Corning	RN60D Series	920-324-92	1		
R80	Resistor, Metal Film, 1%, 51.1K	Corning	RN60D Series	920-351-12	1		
R16, 25	Resistor, Metal Film, 1%, 68.1K	Corning	RN60D Series	920-368-12	2		
R5	Resistor, Metal Film, 1%, 75K	Corning	RN60D Series	920-307-53	1		
R119	Resistor, Metal Film, 1%, 178K	Corning	RN60D Series	920-317-83	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
R41	Resistor, Metal Film, 1%, 619K	Corning	RN60D Series	920-361-93	1		
R19, 39, 42, 122	Potentiometer, 5K, 4TR	Centralab	ZELAFK0001 AD1	960-015-02	4	1	1.00
R13	Potentiometer, 1K	Beckman	79PR1K	960-011-02	1	1	4.98
R11	Resistor, 1/4W, 5% Carbon, 4.7Ω	Allen-Bradley	CB47G5	942-204-79	1		
R29	Resistor, 1/4W, 5% Carbon, 47Ω	Allen-Bradley	CB4705	942-204-70	1		
R61, 108, 115	Resistor, 1/4W, 5% Carbon, 68Ω	Allen-Bradley	CB6805	942-206-80	3		
R51, 106, 107	Resistor, 1/4W, 5% Carbon, 110Ω	Allen-Bradley	CB1115	942-201-11	3		
R37, 38, 49	Resistor, 1/4W, 5% Carbon, 150Ω	Allen-Bradley	CB1515	942-201-51	3		
R110, 114	Resistor, 1/4W, 5% Carbon, 390Ω	Allen-Bradley	CB3915	942-203-91	2		
R30	Resistor, 1/4W, 5% Carbon, 470Ω	Allen-Bradley	CB4715	942-204-71	1		
R24, 27, 34, 46, 55, 58, 62, 128	Resistor, 1/4W, 5% Carbon, 1K	Allen-Bradley	CB1025	942-201-02	8		
R57	Resistor, 1/4W, 5% Carbon, 1.2K	Allen-Bradley	CB1225	942-201-22	1		
R22	Resistor, 1/4W, 5% Carbon, 1.5K	Allen-Bradley	CB1525	942-201-52	1		
R20, 44, 66	Resistor, 1/4W, 5% Carbon, 2.2K	Allen-Bradley	CB2225	942-202-22	3		
R15	Resistor, 1/4W, 5% Carbon, 3.3K	Allen-Bradley	CB3325	942-203-32	1		
R56	Resistor, 1/4W, 5% Carbon, 6.2K	Allen-Bradley	CB6225	942-206-22	1		
R17, 60, 109, 113	Resistor, 1/4W, 5% Carbon, 4.7K	Allen-Bradley	CB4725	942-204-72	4		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
R26,32,54 67,69,72, 74,77,111, 112	Resistor, 1/4W, 5% Carbon, 10K	Allen-Bradley	CB1035	942-201-03	10		
R31,35, 104,105	Resistor, 1/4W, 5% Carbon, 12K	Allen-Bradley	CB1235	942-201-23	4		
R18	Resistor, 1/4W, 5% Carbon, 15K	Allen-Bradley	CB1535	942-201-53	1		
R9,10,21,23 50,52,75	Resistor, 1/4W, 5% Carbon, 22K	Allen-Bradley	CB2235	942-202-23	7		
R33	Resistor, 1/4W, 5% Carbon, 39K	Allen-Bradley	CB3935	942-203-93	1		
R43,47,53 59,65, 102,103	Resistor, 1/4W, 5% Carbon, 47K	Allen-Bradley	CB4735	942-204-73	7		
R125,28	Resistor, 1/4W, 5% Carbon, 68K	Allen-Bradley	CB6835	942-206-83	2		
R48	Resistor, 1/4W, 5% Carbon, 100K	Allen-Bradley	CB1045	942-201-04	1		
R76	Resistor, 1/4W, 5% Carbon, 120K	Allen-Bradley	CB1245	942-201-24	1		
R12,14, 64,118	Resistor, 1/4W, 5% Carbon, 220K	Allen-Bradley	CB2245	942-202-24	4		
R6-8,36, 68,70,73, 78,85	Resistor, 1/4W, 5% Carbon, 330K	Allen-Bradley	CB3345	942-203-34	9		
R84	Resistor, 1/4W, 5% Carbon, 390K	Allen-Bradley	CB3945	942-203-94	1		
R71	Resistor, 1/4W, 5% Carbon, 470K	Allen-Bradley	CB4745	942-204-74	1		
R40,45	Resistor, 1/4W, 5% Carbon, 1.5M	Allen-Bradley	CB1555	942-201-55	2		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
R63	Resistor, 1/4W, 5% Carbon, 3.3M	Allen-Bradley	CB3355	942-203-35	1		
	Thermal Link	Wakefield	259.1	992-010-01	1		
	Heatsink	Thermalloy	2211B	991-001-01	2		
	Transipad	Thermalloy	7717-3N	992-010-50	2		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
Schematic 100-626-05	Reference Board Assembly						
	Circuit Board, Reference	Doric	100-226-06	100-226-06	1		
(Z1)	Integrated Circuit	Motorola	SC 4715G	100-726-00	1		
Q3,4	Transistor, FET, High Leakage	Amelco	U1742	100-722-00	2	1	2.40
Q1	Transistor, 2N4250	National SC	2N42506743	962-425-00	1	1	1.60
Q2	Transistor, 2N3638	Fairchild	F2N3638732	962-363-80	1		
CR1	Diode, Zener, Special	Doric	100-721-01	100-721-01	1		
CR4	Diode, Zener, 6.2V	Transistron	1N753A	961-075-31	1		
CR2,5,6, 7,17	Diode	Cont. Device	1N914	961-091-40	5	2	.50
C2	Capacitor, 22 PF, 10% Disc	RMC	22NPO	901-012-20	1		
C3	Capacitor, .001μFD, 20% Disc	RMC	BA .001Y5U	900-081-03	1		
R28	Resistor, WW, .05%, 49.995K	Mektron	Series C4	934-214-93	1		
R30	Resistor, WW, .05%, 4985.5Ω	Mektron	Series C4	934-214-92	1		
R34	Resistor, WW, .05%, 499.45Ω	Mektron	Series C4	934-214-90	1		
R35	Resistor, WW, .05%, 55.555Ω	Mektron	Series C4	934-215-59	1		
R57	Resistor, WW, .05%, 40K	Mektron	Series C4	934-214-03	1		
R15	Resistor, WW, .05%, 39.9K	Mektron	Series C4	934-213-94	1		
R8,13	Resistor, WW, .05%, 20K	Mektron	Series C4	934-212-03	2		
R5	Resistor, Metal Film, 1.78K, 1%	Corning	RN60C Series	920-317-81	1		
R1,2,3	Resistor, SOT, Metal Film	Corning	RN60D Series	---	3		
R6	Resistor, SOT, Metal Film	Corning	RN60C Series	---	1		
R10,24,26	Resistor, Carbon, 1/4W, 5%, 220K	Allen-Bradley	CB2245	942-202-24	3		
R33	Resistor, Carbon, 1/4W, 5%, 220Ω	Allen-Bradley	CB2215	942-202-21	1		
R56	Resistor, Metal Film, 1K, 1%	Corning	RN60D Series	920-310-01	1		
R32	Resistor, Carbon, 1/4W, 5%, 1.5K	Allen-Bradley	CB1525	942-201-52	1		
R18	Resistor, Carbon, 1/4W, 5%, 390Ω	Allen-Bradley	CB3915	942-203-91	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
R4, 20	Resistor, Carbon, 1/4W, 5%, 8.2K	Allen-Bradley	CB8225	942-208-22	2		
R14	Resistor, Carbon, 1/4W, 5%, 10K	Allen-Bradley	CB1035	942-201-03	1		
R11, 27	Resistor, Carbon, 1/4W, 5%, 22K	Allen-Bradley	CB2235	942-202-23	2		
R19	Resistor, Carbon, 1/4W, 5%, 470K	Allen-Bradley	CB4745	942-204-74	1		
R21	Resistor, Carbon, 1/4W, 5%, 120K	Allen-Bradley	CB1245	942-201-24	1		
R12, 23, 44	Resistor, Carbon, 1/4W, 5%, 1 meg	Allen-Bradley	CB1055	942-201-05	3		
R9	Resistor, Carbon, 1/4W, 5%, 330K	Allen-Bradley	CB3345	942-203-34	1		
R29, 31	Potentiometer, 10Ω	CTS	P115R100A	960-011-00	2		
R16, 22	Potentiometer, 250Ω	CTS	P115R251A	960-012-51	2		
R7	Potentiometer, 1K	Beckman	79PR1K	960-011-02	1		
R17, 25	Potentiometer, 5K, 4TR	Centralab	ZELAFK0001 AD1	960-015-02	2		
C4	Capacitor, .002μFD, 20%, Disc	RMC	BA .002Z5U	900-082-03	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
Schematic 100-628-04	Digital Board Group Assembly						
	Circuit Board, Digital	Doric	100-228-03	100-228-03	1		
Z14,17, 20,23	Integrated Circuit, CμL821	Fairchild	995879	965-501-01	4	1	11.20
Z15,18,21, 24	Integrated Circuit, CμL820	Fairchild	995979	965-501-02	4	1	10.05
Z16,19, 22,25	Integrated Circuit, CμL817	Fairchild	996079	965-501-03	4	1	15.70
Z8,9,26, 27	Integrated Circuit, CμL	Fairchild	92328-751	965-500-09	4	1	4.02
Z1-7, 10-13	Integrated Circuit, CμL	Fairchild	91428-751	965-500-00	11		
Q10-12, 14,8,19	Transistor, 2N3877A	G. E.	2N3877A	962-387-71	6		
Q17	Transistor, 2N3567	Fairchild	F2N3567814	962-356-70	1		
Q15	Transistor, 2N3638	Fairchild	F2N3638732	962-363-80	1		
Q1-7,9, 13,16	Transistor, 2N3393	G. E.	2N3393	962-339-30	10		
Q18	Transistor, 2N5296	RCA	2N5296	962-529-60	1	1	3.96
CR10-12	Diode, 1N914	Cont. Device	1N914	961-091-40	3		
CR2-9	Rectifier, SCE-2	Semtech	6824	966-002-00	8	1	1.20
CR1	Rectifier, SCE-6	Semtech	6812	966-002-04	1	1	1.62
C3,14	Capacitor, .22μFD, 10%, Polycarb.	Elpac	B1A224J	911-032-24	2		
C5,31	Capacitor, .01μFD, 20%, Disc	RMC	TA.01Y5U	900-021-04	2		
C2,6,7, 13,15	Capacitor, .001μFD, 20%, Disc	RMC	BA.001Y5U	900-081-03	5		
C4,19,20,23	Capacitor, 100 PF, 10%, Disc	RMC	JL100X5F	901-011-01	4		
C16	Capacitor, 330 PF 10%, Disc	RMC	JL330X5F	901-013-31	1		
C17	Capacitor, .068μFD, 5% Polycarb.	Elpac	B1A683J	911-036-83	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
C29	Capacitor, 5000μFD @10V, Electrolytic	Sprague	39D508G010-HP4	910-025-09	1	1	2.82
C27,28	Capacitor, 1100μFD @50V, Electrolytic	Sprague	39D118G050-HP4	910-041-18	2	1	2.82
C26	Capacitor, 100μFD @250V, Electrolytic	Sprague	39D107F250-HL4	910-061-07	1	1	2.79
C1	Capacitor, 25μFD @6V, Electrolytic	Sprague	30D256G006-BB2	910-032-56	1	1	1.00
C18	Capacitor, .005μFD, 100V, 20%, Disc	RMC	TA.005 Z5V	900-050-54	1		
C8,9,10	Capacitor, .01μFD, 10% Polycarb	Elpac	B5A103K	911-031-04	3	1	1.95
R64	Resistor, Carbon, 1/2W, 5% 15Ω	Allen-Bradley	EB1505	942-301-50	1		
R52-55	Resistor, Carbon, 1/2W, 5% 22K	Allen-Bradley	EB2235	942-302-23	4		
R57	Resistor, Carbon, 1/2W, 5%, 39K	Allen-Bradley	EB3935	942-303-93	1		
R56	Resistor, Carbon, 1/2W, 5%, 47K	Allen-Bradley	EB4735	942-304-73	1		
R24	Resistor, Carbon, 1/4W, 5%, 390Ω	Allen-Bradley	CB3915	942-203-91	1		
R43	Resistor, Carbon, 1/4W, 5%, 470Ω	Allen-Bradley	CB4715	942-204-71	1		
R25	Resistor, Carbon, 1/4W, 5%, 680Ω	Allen-Bradley	CB6815	942-206-81	1		
R46,47,48,51, 8,28,33,34 41	Resistor, Carbon, 1/4W, 5%, 1K	Allen-Bradley	CB1025	942-201-02	9		
R20	Resistor, Carbon, 1/4W, 5%, 1.2K	Allen-Bradley	CB1225	942-201-22	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
R30,31, 32	Resistor, Carbon, 1/4W, 5%, 1.5K	Allen-Bradley	CB1525	942-201-52	3		
R67	Resistor, Carbon, 1/4W, 5%, 1.8K	Allen-Bradley	CB1825	942-201-82	1		
R22,27,66	Resistor, Carbon, 1/4W, 5%, 2.2K	Allen-Bradley	CB2225	942-202-22	3		
R21	Resistor, Carbon, 1/4W, 5%, 3.3K	Allen-Bradley	CB3325	942-203-32	1		
R13,17-19, 23,26,29 36,37,42, 59,63,65, 70,71,75	Resistor, Carbon, 1/4W, 5%, 4.7K	Allen-Bradley	CB4725	942-204-72	16		
R5,12,15, 16,81,69,4	Resistor, Carbon, 1/4W, 5%, 10K	Allen-Bradley	CB1035	942-201-03	7		
R7,11,62	Resistor, Carbon, 1/4W, 5%, 15K	Allen-Bradley	CB1535	942-201-53	3		
R2,39,60, 73,77,80,6	Resistor, Carbon, 1/4W, 5%, 47K	Allen-Bradley	CB4735	942-204-73	7		
R3,79	Resistor, Carbon, 1/4W, 5%, 75K	Allen-Bradley	CB7535	942-207-53	2		
R14,40, 61,74,78	Resistor, Carbon, 1/4W, 5%, 150K	Allen-Bradley	CB1545	942-201-54	5		
R1,35,38, 58,72,76	Resistor, Carbon, 1/4W, 5%, 330K	Allen-Bradley	CB3345	942-203-34	6		
R68	Potentiometer, 5K, 4TR	Centralab	ZELAFK0001 AD1	960-015-02	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
F2	Fuse, 1 amp, Pigtail 3AGSBPT	Littlefuse	315001	971-060-01	1	1	.69
L1	Choke, 240μh	Delvin	1537-94	967-005-01	1		
	Socket, Nixie	Burroughs	SK-196	992-001-01	4		
V1,2,3,4	Indicators, Nixie	Burroughs	B5441A	968-050-01	4	1	11.00
	Heatsink	Doric	100-227-02	100-227-02	1		
	Doric Logo	Doric	100-251-00	100-251-00	1		
	Knob, Power/Sample Rate	Doric	100-221-02	100-221-02	1		
	Symbol Board	Doric	100-242-04	100-242-04	1		
DS1-8	Neon Indicators	G. E.	NE-2H	968-010-01	8	1	.45
	Symbol Block	Doric	100-217-01	100-217-01	1		
	Mounting Bracket, Switch	Doric	100-216-02	100-216-02	1		
	Front Panel, Upper	Doric	100-209-02	100-209-02	1		
	Symbol Film	Doric	100-240-02	100-240-02	1		
S1	Switch, Power	Mallory	US26	969-100-01	1	1	1.60
R9	Potentiometer, Sample Rate, 100K	Mallory	U39	960-011-04	1	1	2.31
J5	Connector, 2 pin	Winchester	JF2P2S	973-020-01	1		
	Ringnut	Eldema	141-10003-010	991-030-01	1		
C32	Capacitor, Trim, 170PF to 780PF	Arco-Elmenco	469	914-100-00	1		

7-3. INDIVIDUAL PARTS

K AND P SERIES

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
	K1 Plug-in Single range, 10MV, F.S. Add:						
Schematic 100-625-05	Front Panel, Lower	Doric	100-250-00	100-250-00	1 Add:		
Q6A, 6B	Transistor, Dual, Special (replaces P/N 100-724-00)	Doric	100-725-00	100-725-00	1 Replace: 1		58.80
	The following parts are removed from the Reference Board Assembly:						
Schematic 100-626-05					Remove:		
R30	Resistor, WW, .05%, 4985.5Ω	Mektron	Series C4	934-214-92	1		
R34	Resistor, WW, .05%, 499.45Ω	Mektron	Series C4	934-214-90	1		
R24, 26	Resistor, Carbon, 1/4W, 5%, 220K	Allen-Bradley	CB2245	942-202-24	2		
R33	Resistor, Carbon, 1/4W, 5%, 220Ω	Allen-Bradley	CB2215	942-202-21	1		
R27	Resistor, Carbon, 1/4W, 5%, 22K	Allen-Bradley	CB2235	942-202-23	1		
R21	Resistor, Carbon, 1/4W, 5%, 120K	Allen-Bradley	CB1245	942-201-24	1		
R23, 44	Resistor, Carbon, 1/4W, 5%, 1 meg	Allen-Bradley	CB1055	942-201-05	2		
R29, 31	Potentiometer, 10Ω	CTS	P115R100A	960-011-00	2		
R22	Potentiometer, 250Ω	CTS	P115R251A	960-012-51	1		
R25	Potentiometer, 5K, 4TR	Centralab	ZELAFK0001 AD1	960-015-02	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
	K2 Plug-in Single Range 100MV, F.S.						
Schematic 100-625-05	Add: Front Panel, Lower	Doric	100-250-00	100-250-00	1		
	The following parts are removed from the Reference Board Assembly:						
Schematic 100-626-05					Remove:		
R30	Resistor, WW, .05%, 4985.5 Ω	Mektron	Series C4	934-214-92	1		
R35	Resistor, WW, .05%, 55.555 Ω	Mektron	Series C4	934-215-59	1		
R24, 26	Resistor, Carbon, 1/4W, 5% 220K	Allen-Bradley	CB2245	942-202-24	2		
R33	Resistor, Carbon, 1/4W, 5%, 220 Ω	Allen-Bradley	CB2215	942-202-21	1		
R27	Resistor, Carbon, 1/4W, 5%, 22K	Allen-Bradley	CB2235	942-202-23	1		
R21	Resistor, Carbon, 1/4W, 5%, 120K	Allen-Bradley	CB1245	942-201-24	1		
R23, 44	Resistor, Carbon, 1/4W, 5%, 1 meg	Allen-Bradley	CB1055	942-201-05	2		
R29, 31	Potentiometer, 10 Ω	CTS	P115R100A	960-011-00	2		
R22	Potentiometer, 259 Ω	CTS	P115R251A	960-012-51	1		
R25	Potentiometer, 5K, 4TR	Centralab	ZELAFK0001 AD1	960-015-02	1		
Schematic 100-625-05	Remove from Analog Board Assembly:						
R13	Potentiometer, 1K	Beckman	79PR1K	960-011-02	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
	K3 Plug-in Single Range, 1V, F.S. Add:						
Schematic 100-625-05	Front Panel, Lower	Doric	100-250-00	100-250-00	Add: 1		
	The following parts are removed from the Reference Board Assembly:						
Schematic 100-626-05					Remove:		
R34	Resistor, WW, .05%, 499.45Ω	Mektron	Series C4	934-214-90	1		
R35	Resistor, WW, .05%, 55.555Ω	Mektron	Series C4	934-215-59	1		
R24, 26	Resistor, Carbon, 1/4W, 5%, 220K	Allen-Bradley	CB2245	942-202-24	2		
R33	Resistor, Carbon, 1/4W, 5%, 220Ω	Allen-Bradley	CB2215	942-202-21	1		
R27	Resistor, Carbon, 1/4W, 5%, 22K	Allen-Bradley	CB2235	942-202-23	1		
R21	Resistor, Carbon, 1/4W, 5%, 120K	Allen-Bradley	CB1245	942-201-24	1		
R23, 44	Resistor, Carbon, 1/4W, 5%, 1 meg	Allen-Bradley	CB1055	942-201-05	2		
R29, 31	Potentiometer, 10Ω	CTS	P115R100A	960-011-00	2		
R22	Potentiometer, 250Ω	CTS	P115R251A	960-012-51	1		
R25	Potentiometer, 5K, 4TR	Centralab	ZELAFK0001 AD1	960-015-02	1		
Schematic 100-625-05	Remove from Analog Board Assembly:						
R13	Potentiometer, 1K	Beckman	79PR1K	960-011-02	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
	K4 Plug-in Single Range 10V, F.S.						
Schematic	Add:				Add:		
100-625-05	Front Panel, Lower	Doric	100-250-00	100-250-00	1		
	The following parts are removed from the Reference Board Assembly:						
Schematic 100-625-05					Remove:		
R28	Resistor, WW, .05%, 49.995K	Mektron	Series C4	934-214-93	1		
R30	Resistor, WW, .05%, 4985.5Ω	Mektron	Series C4	934-214-92	1		
R34	Resistor, WW, .05%, 499.45Ω	Mektron	Series C4	934-214-90	1		
R35	Resistor, WW, .05%, 55.555Ω	Mektron	Series C4	934-215-59	1		
R24,26	Resistor, Carbon, 1/4W, 5%, 220K	Allen-Bradley	CB2245	942-202-24	2		
R33	Resistor, Carbon, 1/4W, 5%, 220Ω	Allen-Bradley	CB2215	942-202-21	1		
R27	Resistor, Carbon, 1/4W, 5%, 22K	Allen-Bradley	CB2235	942-202-23	1		
R21	Resistor, Carbon, 1/4W, 5%, 120K	Allen-Bradley	CB1245	942-201-24	1		
R23,44	Resistor, Carbon, 1/4W, 5%, 1 meg	Allen-Bradley	CB1055	942-201-05	2		
R29,31	Potentiometer, 10Ω	CTS	P115R100A	960-011-00	2		
R22	Potentiometer, 250Ω	CTS	P115R251A	960-012-51	1		
R25	Potentiometer, 5K, 4TR	Centralab	ZELAFK0001 AD1	960-015-02	1		
Schematic 100-625-05	Remove from Analog Board Assembly:				Remove:		
R13	Potentiometer, 1K	Beckman	79PR1K	960-011-02	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
	K5 Plug-in 4 range, 10MV-10V, F.S.						
Schematic 100-625-05	Add to Analog Board Assembly:						
	Front Panel, Lower	Doric	100-247-00	100-247-00	1	Add:	
S3-6	Switch, 4-position, pushbutton	Centralab	2XCC000400-170	969-010-00	1	Add:	
Q6A, 6B	Transistor, Dual, Special (replace P/N100-724-00)	Doric	100-725-00	100-725-00	1	Replace: 1	58.80

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
	K5A Plug-in 4 Range, 1V-750V, F.S.						
Schematic 100-625-05	Add to Analog Board Assembly:				Add:		
	Front Panel, Lower	Doric	100-246-00	100-246-00	1		
S1-4	Switch, 4-position, pushbutton	Centralab	2XCC000400-170	969-010-00	1		
R1	Resistor, Metal Film, .1%, 10 megΩ	I.R.C.	MEH T-9 Series	922-510-05	1		
K1	Relay, 24V	Parelco	R10-E595	970-001-01	1		
R2	Resistor, WW, .05%, 100.909K	Mektron	Series C4	934-211-03	1		
R3	Potentiometer, 250Ω	CTS	P115R251A	960-012-51	1		
	Remove:						
R13	Potentiometer, 1K	Beckman	79PR1K	960-011-02	1 Remove		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
	K6 Plug-in 6 Range, 10MV-750V, F.S.						
Schematic 100-625-05	Add to Analog Board Assembly:				Add:		
	Front Panel, Lower	Doric	100-210-03	100-210-03	1		
S1-6	Switch, 6 position, pushbutton	Centralab	2XCC000600-171	969-010-02	1		
R1	Resistor, Metal Film, .1%, 10 megΩ	I.R.C.	MEH T-9 Series	922-510-05	1		
K1	Relay, 24V	Parelco	R10-E595	970-001-01	1		
R2	Resistor, WW, .05%, 100.909K	Mektron	Series C4	934-211-03	1		
R3	Potentiometer, 250Ω	CTS	P115R251A	960-012-51	1		
Q6A, 6B	Transistor, Dual Special (replace P/N 100-724-00)	Doric	100-725-00	100-725-00	1	Replace 1	58.80

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
	P1 Plug-in 4 range, 1V-750V, F.S.						
Schematic 100-625-05	Add to Analog Board Assembly:				Add:		
	Front Panel, Lower	Doric	100-246-00	100-246-00	1		
S1-4	Switch, 4 position, pushbutton	Centralab	2XCC000400-170	969-010-00	1		
R1	Resistor, Metal Film, .1%, 10 megΩ	I.R.C.	MEH T-9 Series	922-510-05	1		
K1	Relay, 24V	Parelco	R10-E595	970-001-01	1		
R2	Resistor, WW, .05%, 100.909K	Mektron	Series C4	934-211-03	1		
R3	Potentiometer, 250Ω	CTS	P115R251A	960-012-51	1		
Z2	Integrated Circuit, CμL 817	Fairchild	996079	965-501-03	1		
Q31-38	Transistor, FET - High Leakage	Amelco	U1742	100-722-00	8		
Q43	Transistor, 2N3638	Fairchild	F2N3638732	962-363-80	1		
Q39-42	Transistor, 2N3877A	G.E.	2N3877A	962-387-71	4		
CR18-26, 28, 29, 31-34	Diode, 1N914	Cont. Dev.	1N914	961-091-40	15		
R98-101	Resistor, Carbon, 1/4W, 5%, 4.7K	Allen-Bradley	CB4725	942-204-72	4		
R96-97	Resistor, Carbon, 1/4W, 5%, 22K	Allen-Bradley	CB2235	942-202-23	2		
R87	Resistor, Carbon, 1/4W, 5%, 330K	Allen-Bradley	CB3345	942-203-34	1		
R92-95	Resistor, Carbon, 1/4W, 5%, 470K	Allen-Bradley	CB4745	942-204-74	4		
R86, 88-90	Resistor, Carbon, 1/4W, 5%, 1 meg	Allen-Bradley	CB1055	942-201-05	4		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
R91	Resistor, Carbon, 1/4W, 5%, 3.3 meg Remove from Analog Board Assembly	Allen-Bradley	CB3355	942-203-35	1		
R13	Potentiometer, 1K	Beckman	79PR1K	960-011-02	1 Remove:		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
	P2 Plug-in 6 Range, 10MV-750V, F.S.						
Schematic 100-625-05	Add to Analog Board Assembly: Front Panel, Lower	Doric	100-210-03	100-210-03	Add: 1		
S1-6	Switch, 6 position, pushbutton	Centralab	2XCC000600-171				
R1	Resistor, Metal Film, .1%, 10 megΩ	I.R.C.	MEH T-9 Series	922-510-05	1		
K1	Relay, 24V	Parelco	R10-E595	970-001-01	1		
R2	Resistor, WW, .05%, 100.909K	Mektron	Series C4	934-211-03	1		
R3	Potentiometer, 250Ω	CTS	P115R251A	960-012-51	1		
Z2	Integrated Circuit, CμL 817	Fairchild	996079	965-501-03	1		
Q31-38	Transistor, FET - High Leakage	Amelco	U1742	100-722-00	8		
Q43	Transistor, 2N3638	Fairchild	F2N3638732	962-363-80	1		
Q39-42	Transistor, 2N3877A	G.E.	2N3877A	962-387-71	4		
CR18-26, 28, 29, 31-34	Diode, 1N914	Cont. Device	1N914	961-091-40	15		
R98-101	Resistor, Carbon, 1/4W, 5%, 4.7K	Allen-Bradley	CB4725	942-204-72	4		
R96,97	Resistor, Carbon, 1/4W, 5%, 22K	Allen-Bradley	CB2235	942-202-23	2		
R87	Resistor, Carbon, 1/4W, 5%, 330K	Allen-Bradley	CB3345	942-203-34	1		
R92-95	Resistor, Carbon, 1/4W, 5%, 470K	Allen-Bradley	CB4745	942-204-74	4		
R86,88-90	Resistor, Carbon, 1/4W, 5%, 1 meg	Allen-Bradley	CB1055	942-201-05	4		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
R91	Resistor, Carbon, 1/4W, 5%, 3.3 meg	Allen-Bradley	CB3355	942-203-35	1		
Q6A, 6B	Transistor, Dual Special (replaces P/N 100-724-00)	Doric	100-725-00	100-725-00	1	Replace: 1	58.80

7-4. OPTIONS

OPTION B - Self-Check (Sheet 1 of 1)

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
	Option B - Self Check						
					Add:		
Schematic 100-625							
S-7	Pushbutton	Switchcraft	903	969-010-20	1		
	Bracket, Self-Check	Doric	100-244-00	100-244-00	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
Schematic 100-626-05	Option C - DC/DC Ratios The following parts are added to Reference Board Assembly 100-426.				Add:		
Z2	Integrated Circuit	Motorola	MC 4715G	100-726-00	1		
CR8,9,11, 13,14,18	Diode, 1N914	Cont. Dev.	1N914	961-091-40	6		
R43	Resistor, WW, .05%, 2.495K	Mektron	Series C4	934-212-43	1		
R46	Resistor, WW, .05%, 2.855K	Mektron	Series C4	934-212-82	1		
R36	Resistor, Carbon, 1/4W, 5%, 10K	Allen-Bradley	CB1035	942-201-03	1		
R39	Resistor, Carbon, 1/4W, 5%, 8.2K	Allen-Bradley	CB8225	942-208-22	1		
R58	Resistor, Carbon, 1/4W, 5% 390Ω	Allen-Bradley	CB3915	942-203-91	1		
R38	Resistor, Carbon, 1/4W, 5% 470K	Allen-Bradley	CB4745	942-204-74	1		
R50	Resistor, Carbon, 1/4W, 5% 56K	Allen-Bradley	CB5635	942-205-63	1		
R42	Resistor, Carbon, 1/4W, 5% 100K	Allen-Bradley	CB1045	942-201-04	1		
R40	Resistor, Carbon, 1/4W, 5% 220K	Allen-Bradley	CB2245	942-202-24	1		
R49	Resistor, Carbon, 1/4W, 5% 1 meg	Allen-Bradley	CB1055	942-201-05	1		
R45	Potentiometer, 10Ω	CTS	P115R100A	960-011-00	1		
R37, 41, 51	Potentiometer, 5K, 4TR	Centralab	2ELAFK0001 AD1	960-015-02	3		
S1	Switch, Slider	Continental Wirt	G126	969-010-30	1		
C7	Capacitor, .002μFD, 20% Disc	RMC	BA .002Z5U	900-082-03	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
Schematic 100-625-05	Option E - High Speed Analog Board Assembly 100-425 - add the following:				Add:		
C15	Capacitor, 22PF, 10%, Disc	RMC	22NPO	901-012-20	1		
Schematic 100-625-05	The following components replace existing components on the Analog Board Assembly 100-425				Replace:		
C1	Capacitor, .01μF, Polystyrene (replaces P/N 913-042-24)	Elpac	PD5A103K	913-031-04	1		
C2	Capacitor, .001μF, 20%, Disc (replaces P/N 913-036-83)	RMC	BA.001Y5U	900-081-03	1		
C17	Capacitor, .068μF, Polycarb. (replaces P/N 911-032-24)	Elpac	B1A683J	911-036-83	1		
R41	Resistor, Metal Film, 1%,100K (replaces P/N 920-361-93)	Corning	RN60D Series	920-310-03	1		
R64	Resistor, Carbon, 1/4W, 5%, 22K (replaces P/N942-202-24)	Allen-Bradley	CB2235	942-202-23	1		
R76	Resistor, Carbon, 1/4W, 5%, 47K (replaces P/N942-201-24)	Allen-Bradley	CB4735	942-204-73	1		
Schematic 100-628-04	The following components replace existing components on the Digital Board Assembly 100-428						
Q8	Transistor, 2N3606 (replaces P/N 962-387-71)	G.E.	2N3606	962-360-60	1	1	.84
C1	Capacitor, Electrolytic, 3MFD @25V (replaces P/N 910-032-56)	Sprague	30D.TE1201.1	910-030-36	1		
C10	Capacitor, 330PF, 10%, Disc (replaces P/N 911-031-04)	RMC	JL330X5F	901-013-31	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
C16	Capacitor, 100PF, 10%, Disc (replaces P/N 901-013-31)	RMC	JL100X5F	901-011-01	1		
R21	Resistor, Carbon, 1/4W, 5%, 1K (replaces P/N942-203-32)	Allen-Bradley	CB1025	942-201-02	1		
R14	Resistor, Carbon, 1/4W, 5% 4.7K (replaces P/N942-201-54)	Allen-	CB4725	942-204-72	1		
	Remove the following:				Remove:		
C8	Capacitor, .01μFD, Polycarbonate, 10%	Elpac	B5A103K	911-031-04	1		
C32	Capacitor, Trim, 170-780PF	Arco-Elmenco	469	914-100-00	1		
	Add the following:				Add:		
XTAL 1	Crystal, 600KC	Texas Crystals	TC-6	100-781-00	1	1	15.75
	Crystal Holder	Augat	8000-AG-6	992-010-00	1		

OPTION W - RACK ADAPTER (Sheet 1 of 1)

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
	Option W-Rack Adapter						
	Filler Panel	Doric	100-235-01	100-235-01	1		
	Support Bar, Front	Doric	100-232-00	100-232-00	1		
	Support Bar, Rear	Doric	100-231-00	100-231-00	1		
	Rack Mtg Bracket, Right	Doric	100-234-01	100-234-01	1		
	Rack Mtg Bracket, Left	Doric	100-233-01	100-233-01	1		

OPTION X - EXTENDER BOARD (Sheet 1 of 1)

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
	OPTION X, Extender Board						
	Circuit Board, extender	Doric	100-241-00	100-241-00	1		
	Connector	Cinch	251-22-30-341	973-010-08	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
	OPTION Y Rear Signal Inputs In Basic Chassis Assembly:						
	Rear Bezel, 3 input (replaces P/N 100-204-05)	Doric	100-230-04	100-230-04	1 Replace:		
					ADD:		
	Binding Post, White	Pomona	2382-9	973-300-03	1		
	Binding Post, Red	Pomona	2382-2	973-300-02	1		
	Binding Post, Black	Pomona	2382-0	973-300-01	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
	OPTION Z-Signal Input cord set, low thermal						
	In Basic Chassis Assembly						
	REMOVE:				Remove:		
	Input plug, single	Pomona	2944	973-200-01	1		
	Input plug, dual	Pomona	2244	973-200-02	1		
	ADD:				ADD:		
	Special Low Thermal Signal Input Cord Set	Pomona	100-711-00 Doric Spec.	100-711-00	1		

OPTION Z - INPUT CABLE (Sheet 1 of 1)

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
Schematic 100-636-03	Option S3-1 - Output Board Assembly						
	Circuit Board, Output	Doric	100-236-03	100-236-03	1		
Q10	Transistor, 2N3638	Fairchild	F2N3638733	962-363-80	1		
Q1-1 thru 1-26, 2, 4, 5, 8	Transistor 2N3877A	G. E.	2N3877A	962-387-71	30		
Q9	Transistor, 2N3393	G. E.	2N3393	962-339-30	1		
Q3,6	Transistor, 2N4250	National SC	2N42506743	962-425-00	2		
Q2-1 thru 2-26, 7	Transistor, FET	Amelco	U1826E	100-723-00	27	1	2.40
Q1A,1B	Transistor, Dual, FET	Amelco	SU2211	100-724-00	1	1	13.50
CR1-1 thru 1-26, 1,3, 7,9-13, 15-22	Diode, 1N914	Continental Device	1N914	961-091-40	42		
CR5,6,8, 14	Diode, 1N753A	Transitron	1N753A	961-075-31	4		
CR2,4	Diode, 1N702	Continental Device	1N702	961-070-20	2	1	1.32
C8	Capacitor, .068μF, Poly-carbonate	Elpac	B1A683J	911-036-83	1		
C1	Capacitor, 22PF, 10%, Disc	RMC	22NPO	901-012-20	1		
C2,5,6	Capacitor, 100PF, 10%, Disc	RMC	JL100X5F	901-011-01	3		
C4	Capacitor, .001μF, 20%, Disc	RMC	BA.001Y5U	900-081-03	1		
C3,7,9	Capacitor, .01μF, 20%, Disc	RMC	TA.01Y5U	900-021-04	3		
L1	Choke, 240μh	Delvin	1537-94	967-005-01	1		
R7	Resistor, Carbon, 1/4W,5%, 150Ω	Allen-Bradley	CB1515	942-201-51	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
R23,41	Resistor, Carbon, 1/4W, 5%, 470Ω	Allen-Bradley	CB4715	942-201-51	2		
R20,22,36	Resistor, Carbon, 1/4W, 5%, 1K	Allen-Bradley	CB1025	942-201-02	3		
R11	Resistor, Carbon, 1/4W, 5%, 1.8K	Allen-Bradley	CB1825	942-201-82	1		
R12,21	Resistor, Carbon, 1/4W, 5%, 3.3K	Allen-Bradley	CB3325	942-203-32	2		
R3,6	Resistor, Carbon, 1/4W, 5%, 4.7K	Allen-Bradley	CB4725	942-204-72	2		
R2-17	Resistor, Carbon, 1/4W, 5%, 6.2K	Allen-Bradley	CB6225	942-206-22	1		
R5,24-29, 31	Resistor, Carbon, 1/4W, 5%, 10K	Allen-Bradley	CB1035	942-201-03	8		
R2-18 thru 2-26,38,39	Resistor, Carbon, 1/4W, 5%, 15K	Allen-Bradley	CB1535	942-201-53	11		
R2,18,40	Resistor, Carbon, 1/4W, 5%, 22K	Allen-Bradley	CB2235	942-202-23	3		
R13	Resistor, Carbon, 1/4W, 5%, 33K	Allen-Bradley	CB3335	942-203-33	1		
R3-1 thru 3-26, 2-1 thru 2-16, 8,14,15	Resistor, Carbon, 1/4W, 5%, 47K	Allen-Bradley	CB4735	942-204-73	45		
R1,4,9, 33,16,37	Resistor, Carbon, 1/4W, 5%, 100K	Allen-Bradley	CB1045	942-201-04	6		
R1-1 thru 1-26, 19	Resistor, Carbon, 1/4W, 5%, 220K	Allen-Bradley	CB2245	942-202-24	27		
R4-1 thru 4-26,10,17	Resistor, Carbon, 1/4W, 5%, 330K	Allen-Bradley	CB3345	942-203-34	28		
R42	Resistor, Carbon, 1/4W, 5% 12K	Allen-Bradley	CB1235	942-201-23	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
R30	Resistor, Carbon, 1/4W, 5%, 470K	Allen-Bradley	CB4745	942-204-74	1		
R34	Resistor, Carbon, 1/4W, 5%, 680K	Allen-Bradley	CB6845	942-206-84	1		
R35	Resistor, Carbon, 1/4W, 5% 1 meg	Allen-Bradley	CB1055	942-201-05	1		
R32	Resistor, Carbon, 1/4W, 5% 22 meg	Allen-Bradley	CB2265	942-202-26	1		
J1	Connector, 31 pin	Winchester	PQD31S	973-021-01	1		
	Connector, Hood	Doric	100-237-02	100-237-02	1		
	Jack Screw	Amp	5823603	991-040-00	2		
	Cable Clamp and Tie	Panduit	SST-1TM-2	991-056-00	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
Schematic 100-636-03	Option S4-1 Input/Output Board Assembly						
	Circuit Board, Input/Output	Doric	100-236-03	100-236-03	1		
Q10, 11-1 thru 11-5	Transistor, 2N3638	Fairchild	F2N3638733	962-363-80	6		
Q1-1 thru 1-26, 2, 4, 5, 8, 12-4	Transistor 2N3877A	G. E.	2N3877A	962-387-71	31		
Q9, 12-1 thru 12-3, 12-5	Transistor, 2N3393	G. E.	2N3393	962-339-30	5		
Q3, 6	Transistor, 2N4250	National SC	2N42506743	962-425-00	2		
Q2-1 thru 2-26, 10-1 thru 10-5, 7	Transistor, FET	Amelco	U1826E	100-723-00	32	1	2.40
Q1A, 1B	Transistor, Dual FET	Amelco	SU2211	100-724-00	1	1	13.50
CR1-1 thru 1-26, 11-1 thru 11-5, 12-1 thru 12-5, 13-1 thru 13-5, 1, 3, 7, 9-13, 15-22	Diode, 1N914	Continental Device	1N914	961-091-40	57		
CR5, 6, 8, 14	Diode, 1N753A	Transitron	1N753A	961-075-31	4		
CR2, 4	Diode, 1N702	Continental Device	1N702	961-070-20	2	1	1.32

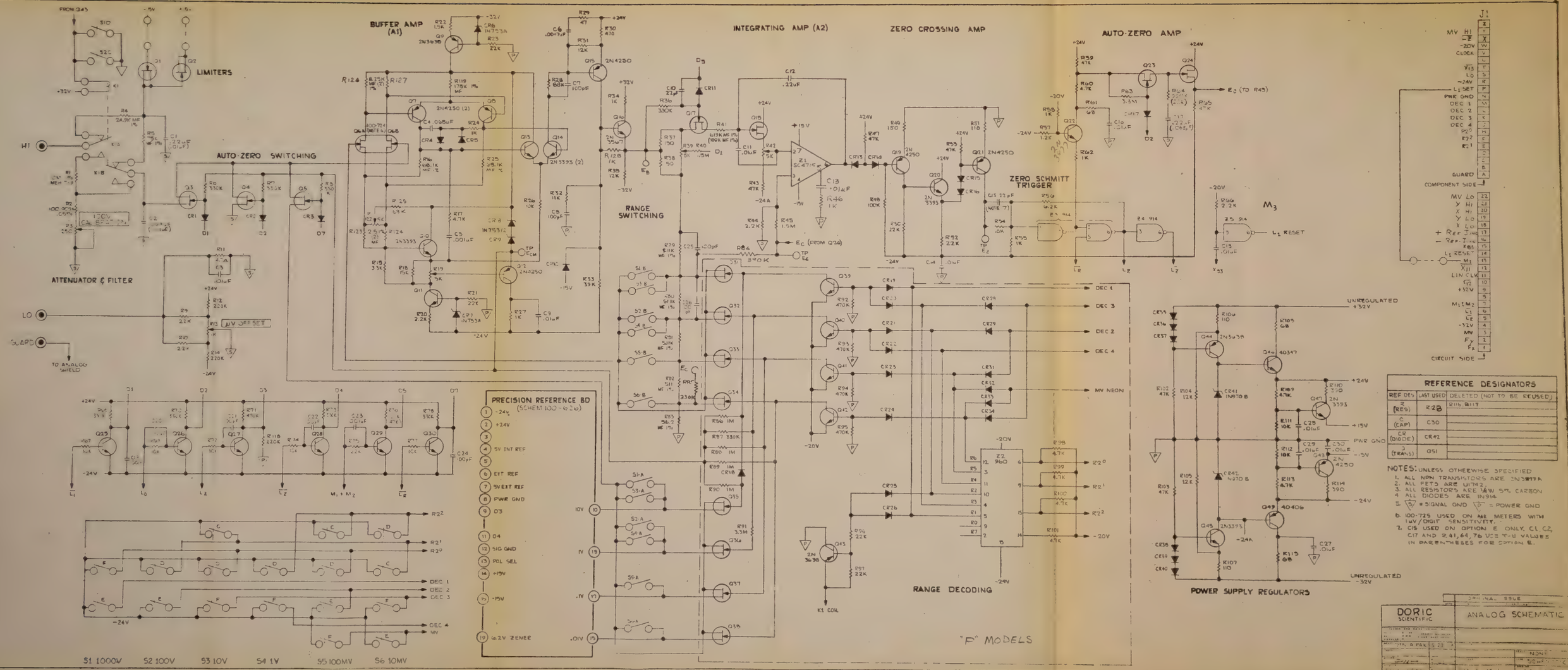
Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
C8	Capacitor, .068μF, Polycarbonate	Elpac	B1A683J	911-036-83	1		
C1	Capacitor, 22PF, 10%, Disc	RMC	22NPOX5F	901-012-20	1		
C2,5,6	Capacitor, 100PF, 10%, Disc	RMC	JL100X5F	901-911-01	3		
C4	Capacitor, .001μF, 20%, Disc	RMC	BA.001Y5U	900-081-03	1		
C3,7,9	Capacitor, .01μF, 20%, Disc	RMC	TA.01Y5U	900-021-04	3		
L1	Choke, 240μh	Delvin	1537-94	967-005-01	1		
R7	Resistor, Carbon, 1/4W, 5%, 150Ω	Allen-Bradley	CB1515	942-201-51	1		
R23,41	Resistor, Carbon, 1/4W, 5%, 470Ω	Allen-Bradley	CB4715	942-204-71	2		
R20,22,36	Resistor, Carbon, 1/4W, 5%, 1K	Allen-Bradley	CB1025	942-201-02	3		
R11	Resistor, Carbon, 1/4W, 5%, 1.8K	Allen-Bradley	CB1825	942-201-82	1		
R12,21	Resistor, Carbon, 1/4W, 5%, 3.3K	Allen-Bradley	CB3325	942-203-32	2		
R3,6	Resistor, Carbon, 1/4W, 5%, 4.7K	Allen-Bradley	CB4725	942-204-72	2		
R2-17	Resistor, Carbon, 1/4W, 5%, 6.2K	Allen-Bradley	CB6225	942-206-22	1		
R5,24-29, 31	Resistor, Carbon, 1/4W, 5%, 10K	Allen-Bradley	CB1035	942-201-03	8		
R2-18 thru 2-26,38,39	Resistor, Carbon, 1/4W, 5%, 15K	Allen-Bradley	CB1535	942-201-53	11		
R10-1 thru 10-5,2, 18,40	Resistor, Carbon, 1/4W, 5%, 22K	Allen-Bradley	CB2235	942-202-23	8		
R13	Resistor, Carbon, 1/4W, 5%, 33K	Allen-Bradley	CB3335	942-203-2	1		

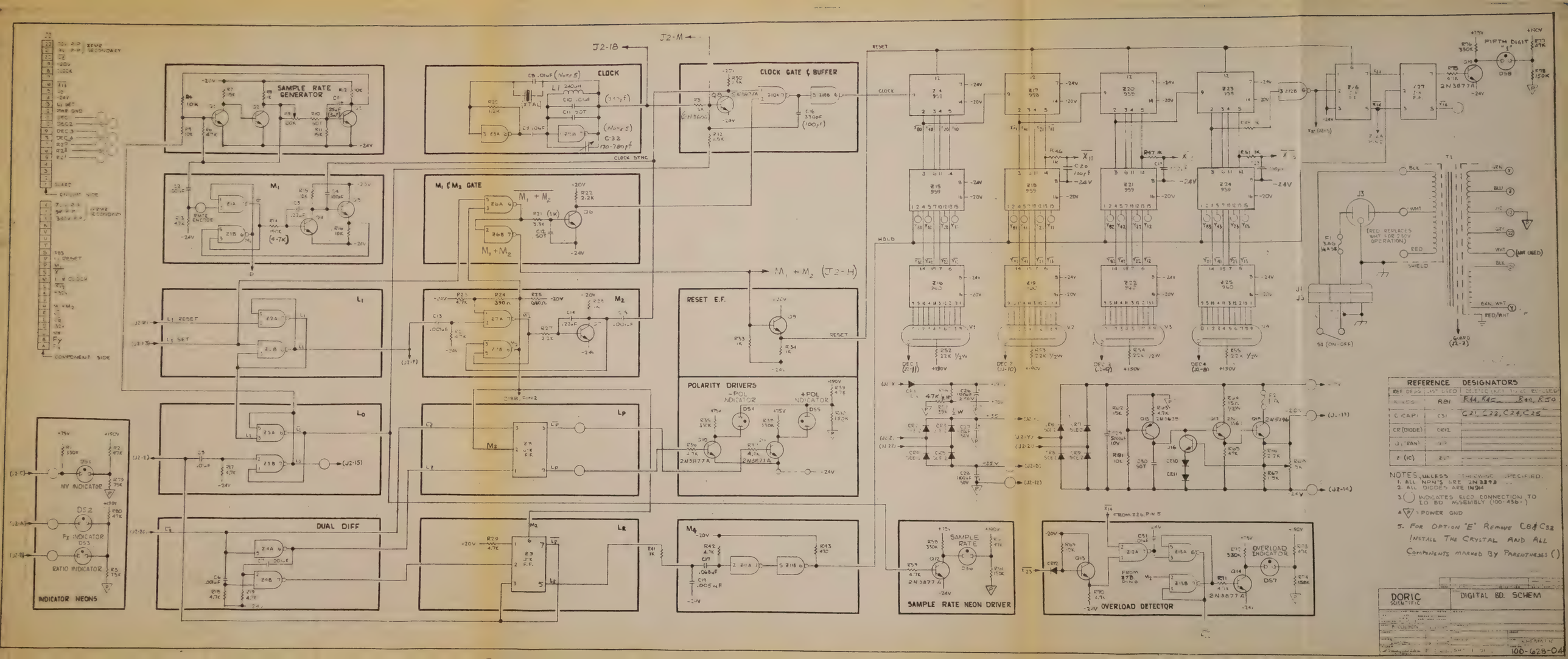
Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
R3-1 thru 3-26, 2-1 thru 2-16, 8, 14, 15	Resistor, Carbon, 1/4W, 5%, 47K	Allen-Bradley	CB4735	942-204-73	45		
R11-1 thru 11-5, 12-1 thru 12-5, 13-1 thru 13-5, 1, 4, 9, 33, 16, 37	Resistor, Carbon, 1/4W, 5%, 100K	Allen-Bradley	CB1045	942-201-04	21		
R1-1 thru 1-26, 19	Resistor, Carbon, 1/4W, 5%, 220K	Allen-Bradley	CB2245	942-202-24	27		
R4-1 thru 4-26, 10, 17	Resistor, Carbon, 1/4W, 5%, 330K	Allen-Bradley	CB3345	942-203-34	28		
R30	Resistor, Carbon, 1/4W, 5%, 470K	Allen-Bradley	CB4745	942-204-74	1		
R34	Resistor, Carbon, 1/4W, 5%, 680K	Allen-Bradley	CB6845	942-206-84	1		
R32	Resistor, Carbon, 1/4W, 5% 22 meg	Allen-Bradley	CB2265	942-202-26	1		
J1	Connector, 31 Pin	Winchester	PQD31S	973-021-01	1		
	Connector Hood	Doric	100-237-02	100-237-02	1		
	Jack Screw	Amp	5823603	991-040-00	2		
	Cable Clamp and Tie	Panduit	SST-1TM-2	991-056-00	1		
R42	Resistor, Carbon, 1/4W, 5% 12K	Allen-Bradley	CB1235	942-201-23	1		
R35	Resistor, Carbon, 1/4W, 5% 1 meg	Allen-Bradley	CB1055	942-201-05	1		

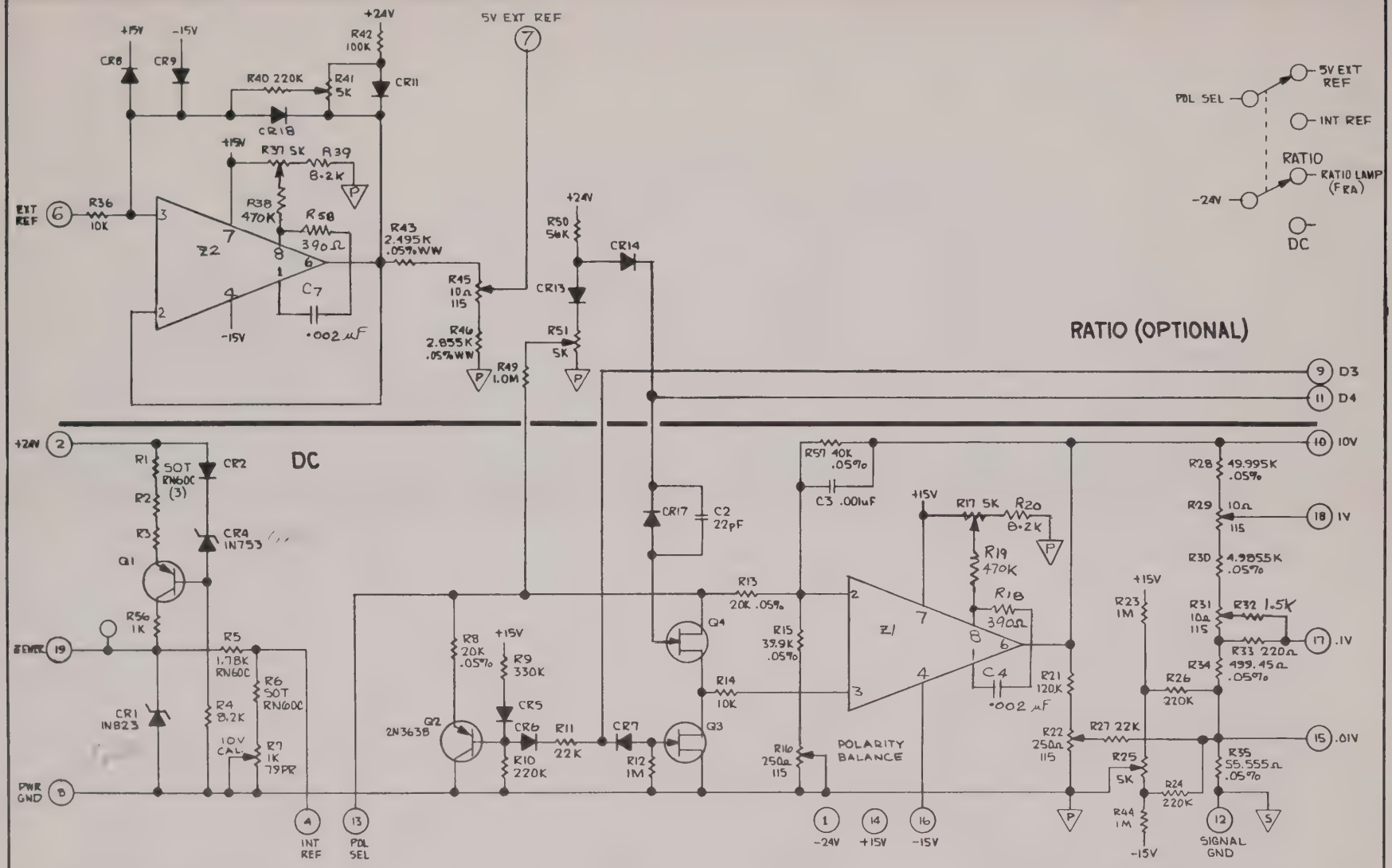
Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
Schematic 100-636-03	Option S4-2 Input Board Assembly						
	Circuit Board, Input	Doric	100-236-03	100-236-03	1		
Q10, 11-1 thru 11-5	Transistor, 2N3638	Fairchild	F2N3638733	962-363-80	6		
Q2, 4, 5, 8, 12-4	Transistor 2N3877A	G. E.	2N3877A	962-387-71	5		
Q9, 12-1 thru 12-3, 12-5	Transistor, 2N3393	G. E.	2N3393	962-339-30	5		
Q3, 6	Transistor, 2N4250	National SC	2N42506743	962-425-00	2		
Q10-1 thru 10-5, 7	Transistor, FET	Amelco	U1826E	100-723-00	6	1	2.40
Q1A, 1B	Transistor, Dual FET	Amelco	SU2211	100-724-00	1	1	13.50
CR11-1 thru 11-5, 12-1 thru 12-5, 13-1 thru 13-5, 1, 3, 7, 9, 15-22	Diode, 1N914	Continental Device	1N914	961-091-40	27		
CR5, 6, 8	Diode, 1N753A	Transitron	1N753A	961-075-31	3		
CR2, 4	Diode, 1N702	Continental Device	1N702	961-070-20	2	1	1.32
C8	Capacitor, .068μF, Polycarbonate	Elpac	B1A683J	911-036-83	1		
C1	Capacitor, 22PF, 10%, Disc	RMC	22NPOX5F	901-012-20	1		
C2, 5, 6	Capacitor, 100PF, 10%, Disc	RMC	JL100X5F	901-011-01	3		
C4	Capacitor, .001μF, 20%, Disc	RMC	BA.001Y5U	900-081-03	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
C3,7,9	Capacitor, .01μF, 20%, Disc	RMC	TA.01Y5U	900-021-04	3		
L1	Choke, 240μh	Delvin	1537-94	967-005-01	1		
R7	Resistor, Carbon, 1/4W, 5%, 150Ω	Allen-Bradley	CB1515	942-201-51	1		
R20,22,36	Resistor, Carbon, 1/4W, 5%, 1K	Allen-Bradley	CB1025	942-201-02	3		
R11	Resistor, Carbon, 1/4W, 5%, 1.8K	Allen-Bradley	CB1825	942-201-82	1		
R12,21	Resistor, Carbon, 1/4W, 5%, 3.3K	Allen-Bradley	CB3325	942-203-32	2		
R3,6	Resistor, Carbon, 1/4W, 5%, 4.7K	Allen-Bradley	CB4725	942-204-72	2		
R5,24-29, 31	Resistor, Carbon, 1/4W, 5%, 10K	Allen-Bradley	CB1035	942-201-03	8		
R10-1 thru 10-5,2,18,40	Resistor, Carbon, 1/4W, 5%, 22K	Allen-Bradley	CB2235	942-202-23	8		
R13	Resistor, Carbon, 1/4W, 5%, 33K	Allen-Bradley	CB3335	942-203-33	1		
R8,14,15	Resistor, Carbon, 1/4W, 5%, 47K	Allen-Bradley	CB4735	942-204-73	3		
R11-1 thru 11-5, 12-1 thru 12-5, 13-1 thru 13-5, 1, 4,9,33,16,37	Resistor, Carbon, 1/4W, 5%, 100K	Allen-Bradley	CB1045	942-201-04	21		
R19	Resistor, Carbon, 1/4W, 5%, 220K	Allen-Bradley	CB2245	942-202-24	1		
R10,17	Resistor, Carbon, 1/4W, 5%, 330K	Allen-	CB3345	942-203-34	2		
R30	Resistor, Carbon, 1/4W, 5%,470K 470K	Allen-Bradley	CB4745	942-204-74	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
R34	Resistor, Carbon, 1/4W, 5%, 680K	Allen-Bradley	CB6845	942-206-84	1		
R32	Resistor, Carbon, 1/4W, 5%, 22 meg	Allen-Bradley	CB2265	942-202-26	1		
J1	Connector, 31 Pin	Winchester	PQD31S	973-021-01	1		
	Connector Hood	Doric	100-237-02	100-237-02	1		
	Jack Screw	Amp	5823603	991-040-00	2		
	Cable Clamp and Tie	Panduit	SST-1TM-2	991-056-00	1		
R41	Resistor, Carbon, 1/4W, 5% 470Ω	Allen-Bradley	CB4715	942-204-71	1		
R42	Resistor, Carbon, 1/4W, 5% 12K	Allen-Bradley	CB1235	942-201-23	1		
R38, 39	Resistor, Carbon, 1/4W, 5% 15K	Allen-Bradley	CB1535	942-201-53	2		
R35	Resistor, Carbon, 1/4W, 5% 1 meg	Allen-Bradley	CB1055	942-201-05	1		


BUFFER AMP (A1)
INTEGRATING AMP (A2)
ZERO CROSSING AMP
AUTO-ZERO AMP
LIMITERS
AUTO-ZERO SWITCHING
RANGE SWITCHING
ZERO SCHMITT TRIGGER
ATTENUATOR & FILTER
PRECISION REFERENCE BD
(SCHEM 100-6-26)
RANGE DECODING
POWER SUPPLY REGULATORS
"P" MODELS
S1 1000V S2 100V S3 10V S4 1V S5 100MV S6 10MV
REFERENCE DESIGNATORS
NOTES: UNLESS OTHERWISE SPECIFIED
1. ALL NPN TRANSISTORS ARE 2N3397A
2. ALL FETS ARE U1742
3. ALL RESISTORS ARE ¼W 5% CARBON
4. ALL DIODES ARE IN914
5. ▽ = SIGNAL GND ▷ = POWER GND
6. 100-725 USED ON AE METERS WITH 1uV/DIGIT SENSITIVITY.
7. C15 USED ON OPTION E ONLY. C1, C2, C17 AND R41, 64, 76 USE T-E VALUES IN PARENTHESES FOR OPTION E.
DORIC SCIENTIFIC
ANALOG SCHEMATIC
ORIGINAL ISSUE
NONE
100-625-05

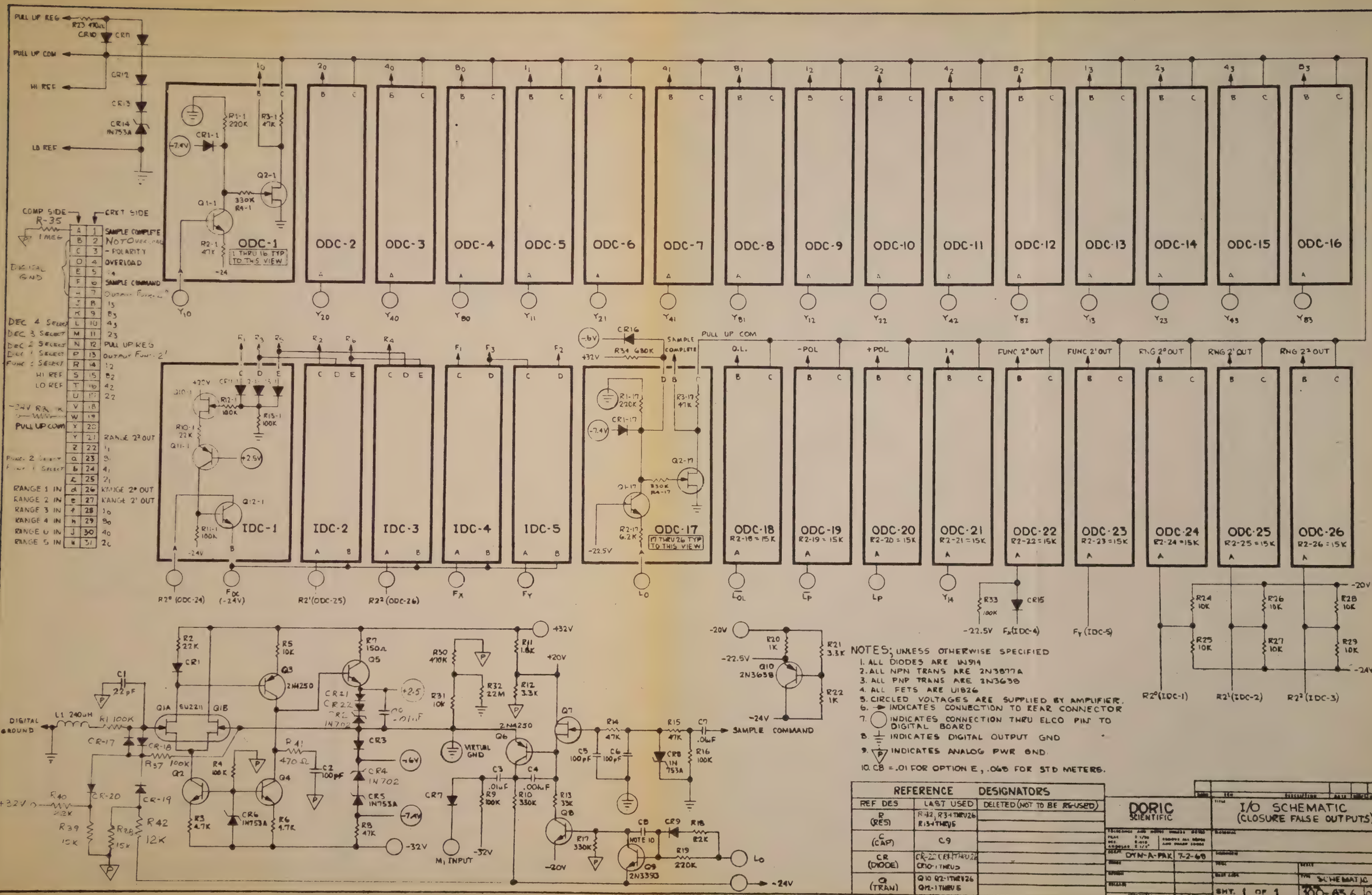

SAMPLE RATE GENERATOR
CLOCK
CLOCK GATE & BUFFER
M1
M1 & M2 GATE
L1
M2
L0
LP
DUAL DIFF
LR
RESET E.F.
POLARITY DRIVERS
SAMPLE RATE NEON DRIVER
OVERLOAD DETECTOR
INDICATOR NEONS
FIFTH DIGIT
REFERENCE DESIGNATORS
NOTES UNLESS OTHERWISE SPECIFIED.
1. ALL NPN'S ARE 2N3393
2. ALL DIODES ARE 1N914
3. ( ) INDICATES ELCO CONNECTION TO IO BD ASSEMBLY (100-458-)
4. ▽ = POWER GND
5. FOR OPTION "E" REMOVE C84 C32 INSTALL THE CRYSTAL AND ALL COMPONENTS MARKED BY PARENTHESES ( )
DORIC SCIENTIFIC
DIGITAL BD. SCHEM
100-628-04



REFERENCE DESIGNATORS		
REF DES	LAST USED	DELETED (NOT TO BE RE-USED)
R (RES)	R58	R52, R53, R54, R55, R47, R48
CR (DIODE)	CR18	CR15, CR16, CR12, CR10 CR3
C (CAP)	C7	C1, C5, C6
Q (TRANS)	Q9	Q5 THRU Q10

NOTES, UNLESS OTHERWISE SPECIFIED
1. ALL RESISTORS ARE 1/4W 5% CARBON.
2. ALL DIODES ARE IN914
3. ALL PNP TRAN'S ARE 2N4250
4. ALL NPN TRAN'S ARE 2N3877A
5. ALL FETS ARE U1742.
6. I.C. ARE SC4715

		ORIGINAL ISSUE	
DORIC SCIENTIFIC		TITLE: REFERENCE SCHEMATIC	
TOLERANCE AND NOTES UNLESS NOTED: FRAC. ± 1/32, DEC. ± .010, ANGULAR ± 1/2°; REMOVE ALL BURRS AND SHARP EDGES		MATERIAL	
DRAFT: DYN-A-PAK	6-13-68	DENOMINATOR	
CHECK		TOOL	SCALE: NONE
DESIGN: PMH	6-15-68	NEXT ASSY.	TYPE: SCHEMATIC
APPROVALS: [illegible]	6-15-68 DATE	SHT. 1 OF 1	DWG. NO. 100-626 05



REFERENCE DESIGNATORS		
REF DES	LAST USED	DELETED (NOT TO BE RE-USED)
R (RES)	R42, R34 THRU 26, R134 THRU 5	
C (CAP)	C9	
CR (DIODE)	CR-22 CR11 THRU 26, CR10-1 THRU 5	
Q (TRAN)	Q10 Q2-1 THRU 26, Q12-1 THRU 5	

DORIC SCIENTIFIC

DYN-A-PAK 7-2-68

I/O SCHEMATIC (CLOSURE FALSE OUTPUTS)

SCHEMATIC

SHT. 1 OF 1

100-0356 03

RANGE SWITCHING

HI

ATTEN. FILTER & LIMITER

LO

μV OFFSET SOURCE

Q3

Q4

Q5

D7

L_R

D1

$\overline{L_1}$

$M_1 + M_2$

D5

BUFFER AMP

G1

G10

G100

G1K

±10V

1V

.1V

.01V

S

BI-POLAR REFERENCE VOLTAGE

SELECT POS REF

SELECT NEG REF

D4

D3

C12

E_B

Q17

R41

INTEG. AMP

ZERO CROSSING AMP

Z3-1

ZERO SCHMITT TRIGGER

L_Z

Z3-6

$\overline{L_Z}$

Z4-6

HOLD

Z3-5

$\overline{L_R}$

Q22

ELECTRONIC OR MECHANICAL SWITCHES

E_C

AUTO-ZERO AMP

Q23

R64

C17

LO

D2

P2 OPTION ONLY

BCD TO DECIMAL RANGE DECODERS

REMOTE RANGE INFO (BCD)

$R2^0$ — 14

$R2^1$ — 11

$R2^2$ — 6

R1
R2
R3
R4
R5
R6

GAIN & REFERENCE CONTROL LINES (TO ELECTRONIC SWITCHES)

TO ATTEN RELAY

ATTEN RELAY DR

G1 — R1 R2

G10 — R1 R3

G100 — R2 R4

G1K — R5

'MV' NEON — R5 R6

DEC 1 — R6

DEC 2 — R1

DEC 3 — R2 R5

DEC 4 — R3 R6

R4

NOTES, UNLESS OTHERWISE SPECIFIED

= ELECTRONIC SWITCH

= INVERTER - DRIVER

= EMITTER FOLLOWER

= OR GATE

REV	DESCRIPTION	DATE	DRAFT	APPV.

DORIC SCIENTIFIC

TOLERANCE AND NOTES UNLESS NOTED
FRAC ±1/32 | DEC ±.010 | ANGULAR ±1/2° | REMOVE ALL BURRS AND SHARP EDGES

DRAFT [illegible] 1-76

CHECK

DESIGN

RELEASE

APPROVALS DATE

TITLE: LOGIC DIAGRAM (ANALOG BD)

MATERIAL

FINISH

TOOL

SCALE

NEXT ASSY

TYPE: SCHEMATIC

SHT. 1 OF 1

DWG NO 100-640 REV 00

SAMPLE RATE CONTROL (FRONT PANEL)

M.V. (ASTABLE, COL Q2)

MONO 50MS (M_1, $\overline{M_1}$)

FF (L_1, $\overline{L_1}$)

FF (L_0, $\overline{L_0}$)

SAMPLE LIGHT +170

CLOCK

MONO M3 (3 μS) (M_3, $\overline{M_3}$)

+ INDIC +170

- INDIC +170

MONO 600uS (M_2, $\overline{M_2}$)

M_1 & M_2 GATE

Q8

CLOCK GATE

$\overline{L_2}$

POLARITY FF (L_P, $\overline{L_P}$)

L_R FF (L_R, $\overline{L_R}$)

MONO 100uS (M_4, $\overline{M_4}$)

HOLD LINE

Q6

$M_1 + M_2$

Q9

RESET LINE

$\overline{X_{23}}$ $\overline{X_{14}}$

FF (X_{14}, $\overline{X_{14}}$)

FF (M_2) (L_{OL}, $\overline{L_{OL}}$)

FF (Y_{14}, $\overline{Y_{14}}$)

BCD COUNTER

GATED CLOCK

STORE LINE

BCD STORAGE REGISTER

ALL DECADES ARE TYPICAL TO THE ONE SHOWN IN DETAIL.

Q14

Q19

BCD TO DECIMAL DECODER/DRIVER

0 1 2 3 4 5 6 7 8 9

9 5 10 4 11 3 12 2 18 1

NIXIE

OVERLOAD 'OL'

5TH DIGIT '1'

+170

+170

	DASH	ECN	DESCRIPTION	DATE	DRAFT.	APPV.
			ORIGINAL ISSUE	—	—	—

DORIC SCIENTIFIC

TITLE: LOGIC DIAGRAM (DIGITAL BOARD)

TOLERANCE AND NOTES UNLESS NOTED: FRAC. ± 1/32, DEC. ± .010, ANGULAR ± 1/2°. REMOVE ALL BURRS AND SHARP EDGES

MATERIAL

DRAFT. DYNA PAK 7-5-68

DENEMATIC

CHECK

TOOL

SCALE

DESIGN

NEXT ASSY.

TYPE CHEM

RELEASE

APPROVALS

DATE

SHT. 1 OF 1

DWG. NO. 102-611

DASH 00